AN ARCHAEOLOGY OF EARLY ENGLISH BOATBUILDING PRACTICE c. 900-1600 AD:

Based mainly on finds from SE England

VOLUME 1. TEXT

For a PhD in Archaeology at the Dept. of Medieval Archaeology, Institute of Archaeology, UCL London.

Re submitted November 2002

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ABSTRACT.

AN ARCHAEOLOGY OF EARLY ENGLISH BOATBUILDING PRACTICE
C.900-1600 AD: Based mainly on finds from SE England

This study sets out to document and investigate evidence of how ship and boat builders worked in England from c. 900 to 1600AD. The whole scale of work is covered from small craft to aspects of work on large ships. The study attempts to show how investigations of nautical archaeological material can shed light on issues of wider archaeological interest such as, changes in; wooded cultural landscapes, technology and craft organisation.

The source material is; two small dugout boat finds and selected ship and boat timbers found recycled in waterfront structures, in London. Historical sources and the results of experimentation are also drawn upon. It is now possible to use the results of the last twenty years of archaeological work to reinterpret the documentary sources. The study is set within a close dating framework provided by recent tree-ring work. Analysis is also made of the way nautical woodwork becomes preserved in archaeological deposits.

The tools, techniques, logistics, procedures and raw materials used by boat and shipbuilders and their ancillary workers are reconstructed in detail. The labour time and quality invested is outlined for worked examples. Changes in technology, tools, the timber used and the organisation of ship and boat yards and ancillary trades are revealed and discussed. An attempt is also made to compare the outline of changing shipwrightry practice with aspects of medieval carpentry practice, in terms of timber use, tools, technology and labour investment. Some insights are gained into the expression of status in this branch of structural woodworking. Lastly, it is shown how the detailed reconstruction of the varied timber sources used by ship and boat builders up to c. 1600 can broaden the current views of historic woodlands.

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1 THE AIMS OF THIS STUDY

1/1 INTRODUCTION

The following quotes from leading writers who have been substantial influences on the lines of enquiry followed in this study are provided to set the scene.

'A knowledge of the fashioning of wood is needed by those who interpret the life of the past from the relics of its arts and economy.' (Edlin 1949,preface).

'The archaeologist must have a practical approach which enables him to appreciate the problems faced by boatbuilders working in wood and the way they solved them...' (Greenhill 1976:20).

'Wood is especially important in any study of water transport.' (McGrail 1987:23).

'The British believe that the history of woodlands
has been dominated by the influence of the sea.'
(Rackham 1976:99) of attitudes since the 16th century.

Even today the notice taken in nautical archaeology of the themes alluded to above is highly variable, even in the specific field of 'boat archaeology'. Boat archaeology may be defined here as- the study, based on material remains, of boats and ships, their building and use in the past. A detailed summary of the central aims and key source material of this study is provided below.

1/2 CENTRAL AIMS OF THIS STUDY

This study sets out to use selected case studies and illustrated summaries of finds of early nautical woodwork to isolate trends in boat and ship building and set them in a wider context. Use is also made of selected historical sources. In each case the following aims are held firmly in mind.

1/2/1 THE RECONSTRUCTION OF THE RAW MATERIALS USED, PRINCIPALLY THE TIMBER AND THEREFORE THE LARGER TREES

For this study boat and ship timbers are seen as silent material witnesses to many and varied trees in the past from late Anglo-Saxon to Elizabethan times (c. 900-1600AD). As for much of that period the growing of trees was heavily influenced, or even strictly controlled by people, ('woodmanship' Rackham 1976:18, Goodburn 1998) the evidence can throw light on an area of cultural landscape history still relatively little studied in the archaeology of the Roman and later periods. Of course by contrast, there is a long tradition of investigating the changing wooded lands of Britain and other parts of Northern Europe in later prehistory, mainly through pollen analysis. However, the cut off point for the trees that provided material for the vessels considered in this study is the transition from the Roman to Early-Saxon periods in the 5th to 6th centuries AD or very much later. Therefore the prehistoric evidence is not considered further here.

Nautical timbers are ecofacts as well as structural artefacts. This type of understanding lead Rackham, the leading pioneer in this field, to study timbers in standing medieval buildings with a view to determining not just their species, but also the age, size and form of tree they were cut from (Rackham 1972, 1976, 1980 etc). From this work insights into the nature of historic patterns of woodland management or woodmanship could be gleaned (see Append 2 for explanations of the woodmanship terminology used in this study). This approach has been developed further in several areas (Goodburn 1991b,) and is used throughout the study where the quality of record allows (Append.2). Trends in the character of English 'treeland' (woodland, wildwood, hedges etc) from c.900 to 1600AD have been identified in pilot studies of woodwork 'on land' (eg. Rackham 1972, 1976, 1986a, Goodburn 1992a, 1994b, 1998 etc.) but little carefully documented, practically grounded systematic work of this kind has been carried out on nautical finds from England. By contrast practical experiments in early medieval boat and ship building in Scandinavia were alerting archaeologists to the potential of this line of enquiry as early as the mid 1960's (Olsen and Crumlin-Pedersen 1968:158).

This work will demonstrate how such investigations can deepen our understanding of both ancient trees and woodmanship and the relationship of boat and ship builders to these semi-natural (sometimes largely natural in wildwood) resources. Issues such as the interrelationship of changing woodworking technology and changing treeland are drawn out (Chapts.5,6,7,9). The impact of using other materials, such as iron fastenings is also briefly discussed (Chapt. 9).

1/2/2 RECONSTRUCTING TOOLKITS

Over the c. 700 year period of this study there were great changes in the tool kits used by English shipwrights, boatbuilders and ancillary workers. The details of many of these changes are systematically examined in this study for the first time (Chapts.5,6,7,9). Some of the changes can be shown to be linked to changes in treeland and woodmanship. The adoption of carvel shipbuilding techniques, for larger vessels, at the end of the period was also a key factor influencing toolkit change.

1/2/3 DOCUMENTING CHANGES IN KEY TECHNIQUES USED

The harvesting and processing of raw materials for ship and boat building involved tools, and different categories of people using them in ways that changed through time (Chapts. 5,6,7,9). The techniques of tool use, or how timbers were shaped, fitted and orientated in a vessel are cultural features in the same vain as pottery manufacture and decoration. The use of various types of distinctive metal or wooden fastenings and waterproofing materials are clearly partly a matter of traditional ie. cultural preference. The use of particular techniques also has social implications in terms of boat or ship yard organisation for example a yard using sawn elements requires a larger specialist work force for the sawing.

1/2/4 RECONSTRUCTING LOGISTICS AND WORK FORCES

If the size and weights of elements of a vessel can be reconstructed and the tools and techniques used are known then estimates of the minimum size of the yard work force can be constructed. Experience gained through serious experimental work, without the widespread use of modern aids, can be fundamental to understanding here. In building a vessel many people were involved indirectly as well as directly at the construction site. Attempts are made in the study to reconstruct the labour investment of these ancillary workers as well as those in the ship or boat yard itself. For example, it is clear that in later medieval England the cleft boards used for building large clinker built ships were bought in from merchants who employed or bought from, 'clovyers' who roughly prepared the material, where the large 'parent' trees were felled (8/14 below). Thus, it can be seen that boat and ship building generated work in rural areas not usually thought of as part of the maritime infrastructure. The total labour investment embodied in a medieval vessel together with the nature and size of materials can fairly be taken as a reflection of the status of the owners or users (Chapts.5,6,7,8,9). In this study sample vessels of humble affiliations such as small dugout boats, are considered together with aspects of the larger vessels more generally the subject of detailed boat archaeological investigations.

1/2/5 TOWARDS AN IMPROVED UNDERSTANDING OF EARLY ENGLISH SHIP AND BOAT BUILDING PRACTICE

The actual work that took place in a ship or boat building operation was a flowing series of activities which can be reconstructed to a greater or lesser extent through the synthesis of the foregoing classes of information. This amalgam of techniques, tools, logistics and materials can be subsumed under the umbrella title 'practice'. Each nautical timber embodies elements of a particular type of ship or boat building practice sometimes particular to a specific region, period or purpose (Chapts.7,3). Simply, an 11th century Scandinavian trading ship frame timber is unarguably a sample of a quite different shipbuilding practice to a frame timber from the Mary Rose of c. 1510.

Thus, we do not need almost complete ship or boat finds to examine aspects of ship or boat building practice, although more complete finds clearly have more potential in other spheres such as the reconstruction of the performance of early craft.

1/2/6 REVEALING WHAT IS DISTINCTIVE TO SHIP AND BOAT BUILDING PRACTICE AND WHAT IS PART OF THE MAINSTREAM OF DEVELOPMENTS IN WOODWORKING TECHNOLOGY

As the writer of this study is obliged to deal with a full range of archaeological evidence for different classes of woodwork in the period from, wattle work through timber frame carpentry to cooperage, on a day to day basis, points of comparison naturally emerge. A full review of all the comparative 'land' data can not be included here but selective points of comparison are bought out where they define key features special to nautical woodworking practice. An example could be English boatbuilders prolonged adherence to the use of radially split oak boards as a main clinker planking material long after it had become a minor material in land carpentry. An attempt is also made to compare the labour investments made in selected ship and boat building projects as against building carpentry (Chapt.9).

1/2/7 WHY CERTAIN IMPORTANT AREAS OF BOAT ARCHAEOLOGY ARE NOT SUBJECT TO STUDY HERE

Space constraints prevent a detailed investigation of several important areas of boat archaeology of this period such as reconstructing, the original form of early vessels in detail, the capacity and performance of vessels or rigging, sailing and navigation. Many of these areas are dealt with in other recent studies or seminal works (eg. Marsden 1994, 1996, or McGrail 1987). Another limiting factor is the fragmentary nature of the vast majority of archaeological evidence found in England which does not allow for the reliable reconstruction of parent vessels in the vast majority of cases (see below and Append6).

1/2/8 A NEED FOR MORE EXPLICIT THEORY IN BOAT ARCHAEOLOGY

Nautical archaeology has developed far enough that several, mainly implicit theoretical approaches are used by workers in the field (Chapt.3). However, crude functionalist explanations for features of boat and ship structure still dominate and technical issues subsume social and other wider questions. In this study boats and ships are seen as social products in the same way that a house or a piece of early metal work is. It is also suggested that they encode social information from the beginning of the building process in the selection of particular materials through the finishing to the use and incorporation into archaeological deposits (Chapt.3).

1/2/9 THE PRINCIPAL SOURCE MATERIAL: A JUSTIFICATION FOR INVESTIGATING FRAGMENTARY BOAT AND SHIP FINDS

Relatively complete vessels such as the Gokstad ship, Skuldelev 1, or the Graveney boat had understandably attracted the vast majority of detailed investigative effort, up to the period when this study was initiated (Brogger and Shetelig 1951, Olsen and Crumlin-Pedersen 1968, and Fenwick ed.1978). The only exceptions being the large collection of fragmentary finds from Bryggen, Norway and to some extent part of the Swedish Kalmar corpus (Christensen 1985, Akerlund 1951). However, during the progress of this prolonged study substantial work has been published on groups of medieval fragmentary finds (McGrail 1993, Marsden 1994, 1996, and Crumlin-Pedersen 1997), although many known collections of similar material elsewhere remain unpublished. Thus, the part of this study which deals with aspects of the building of planked craft dovetails with some of the other recent work (Chapts. 7,8,9,). However, this study is thematic rather than based round a catalogue (although see Append.6 a list of material consulted) and concentrates on the specific areas noted above. These have not been central themes of the other studies (except to some extent in Crumlin-Pedersen 1997 on finds from Hedeby and its region). The key importance of the fragmentary finds is that they are comparatively numerous and greatly expand the small corpus of relatively complete finds.

1/3 SOME TERMS OF REFERENCE

Some explanations are provided below for the limits in the study .

1/3/1 THE GEOGRAPHICAL LIMITS

The geographical focus of the study is material found in the SE of England , particularly in the Thames river system, including the historic port of London. This area was chosen as the collection of material was large and much of it recorded in detail and closely dated. Familiarity was also important as this writer was the main field worker responsible for the recording of the material between 1986 and 99. The comparative material covered in the survey of relevant work (Chapt.2) is nearly all from NW Europe (fig.1). An exception to the SE English geographical limits is made for the extended dugout Kentmere 1, from NW England as it straddles the categories of dugout and planked boats and has not been published in detail (Chapt. 6). As London was well known as an international port during our period the chances of finding the remains of foreign built craft was also considered high. However, the vast majority of the material appears to be relatively locally built according to the tree-ring sourcing of the timber (Append 7) and recurrence of technical details not apparently common elsewhere.

1/3/2 THE PERIOD COVERED

The period c. 900-1600 AD was chosen as it was already known that considerable changes in boat and ship building took place with in the 700 year span, such as the adoption of carvel building methods (see below). The quantity of material evidence was also known to be large. Great social and technological changes also took place, such as the decline of feudalism and rise of mercantilism and development of large scale iron production. Additionally Rackham's work had shown that changes in the types of trees used in carpentry on land were also considerable over the later part of that span c. 1200 –1600 (eg. Rackham 1980:161), implying changes in exploited treeland. A general picture of trends in materials used in land based carpentry or 'treewrighting' has also emerged during the course of this research (Goodburn 1992a, 1995 etc). Thus, it is possible to draw out clear chronological contrasts between land and nautical work in materials of the same date. However, to illustrate developments in investigating the archaeology of boat and shipbuilding it is necessary to stray just outside the c.900-1600AD period for chapter 2.

1/4 SOME KEY TERMS AND CONCEPTS

Before proceeding to the literature survey a brief explanation of the use of several key terms is required. (Also see the glossary Append 1).

1/4/1 THE USE OF THE TERM 'ENGLISH' HERE

The ethnicity or historical affiliations of early boat and ship builders are subjects dealt with extensively in other recent syntheses and are only raised here where directly relevant. However, if it is accepted that boat and ship building practice is a social phenomenon it does follow that regional history will have a complex and enduring influence. Even as early as the 10th century certain details of clinker boat planking such as, the use of rawl-plugged, 'Graveney style' rove nails (Append 9), have currently only been found in material in England (Goodburn 1994a). In that sense we might see that evidence as English. With the aid of tree-ring sourcing of timber the likely origin of a sea going vessel may sometimes be checked although trade in certain types of timber complicates the picture (8/1/4, Append 7). The Anglo-Saxon chronicle records that king Alfred built warships neither of the Frisian nor Danish manner, ie. to an English pattern (Savage 1982:107, Goodburn 1994a).

1/4/2 THE TERMS 'SHIP' AND 'BOAT'

Another potential problem for some scholars is what constitutes a 'boat' and what a 'ship'? There is no substantive problem here if one considers that these concepts are socially defined. It would be ludicrous to suggest to a modern super-tanker crew that the Late Saxon Graveney boat was a 'ship' but Fenwick plausibly suggests that she would have been a 'scip' to the people of the time (Fenwick ed. 1978:196). In other words the loose concept 'ship' has variable meaning outside a particular temporal or social context. For convenience and with reluctance this writer will use the term ship simply to describe large vessels principally used to travel long distances at sea. The term 'boat' refers to any smaller vessels. However, a loose but useful size category might be the 'medium-sized vessel', a coastal trading vessel, estuary barge, or ceremonial barge might fit into this group {See Crumlin-Pedersen 1985 for a Viking period distinction between large ships and 'coasters}.

International master shipwrights?

A key point of note here is that shipbuilding as opposed to boatbuilding was more international. For example, a 1295 a large galley was built in London at least partially under the supervision of a master shipwright from Bayonne (Johnson 1927:425).

1/4/3 THE ORIGIN OF VESSELS

Clearly with mobile structures such as ships the likelihood of their being incorporated into the archaeological record far from where they were built is considerable. However, in recent times in SE England old craft were most commonly abandoned near where they were owned in the region where they were built (Goodburn 1984, Milne et al 1998). The London boat and ship finds are taken here as built with in the SE of England unless there are clear reasons for ascribing an origin elsewhere. In the vast majority of cases tree-ring sourcing the timber (Append 7) of the London finds has suggested an origin in SE England. Tree-ring sourcing of the timbers of the hulked Magor Pill boat also suggests a close regional origin (Nayling 1998). The converse has been found in tree-ring sourcing of the timbers of the 11th century Skuldelev 2 long ship (Bonde and Crumlin-Pedersen 1990) and 13th century galley timbers found in June 1999 in London (Append 6 TYT98 entry), both have boards of Irish origin in them. Trade in shipboard is a complicating factor to be investigated further here (Hutchinson 1994a:150). Small dugout vessels are taken as generally being local vessels. medieval groups often exhibit distinctive features implying a very local tradition of building and rarely seem suitable for long distance travel (Chapt.5).

1/5 SOME BASIC TERMS CONCERNING SYSTEMS OF CONSTRUCTION OF MEDIEVAL BOATS AND SHIPS

It is essential to briefly explain some terms used repeatedly in this text for readers with limited knowledge of boat archaeology.

1/5/1 CLINKER BUILDING

This was the most common system of construction used for planked craft in the whole of the northern half of Europe for most of the period of our study and just about survives in various styles today in SE England and elswhere in NW Europe. Here clinker (or ‘clencher', or 'lapstrake') is taken to mean a system of plank boat building were the hull of a vessel is constructed of a shell of planks (or boards) which are fastened together where they overlap. Usually the upper planking overlaps the lower. The frame elements are fastened into a partly or wholly completed hull shell, made of the planks attached to the backbone assembly (fig. 2).

CARVEL BUILDING

This is a system of construction where, in it's recent form, a vessel is thought of as a 'skeleton' of frame timbers clothed in a 'skin' of planking. The planks butt edge to edge and are not permanently fastened to each other but only to the frames. However, there are forms of construction which produce superficially the same end result but are built according to the reverse conception. The planking may be erected as a temporarily supported shell into which frame timbers are then put (Maarleveld 1994). There is thus no one general system of carvel construction but at least two ideal types ' shell-first' carvel and 'frame-first' carvel (figs.3,4).

MEDIEVAL DUGOUT BOATBUILDING

It is very important to consider that the majority of boats perhaps up to the late medieval period in Britain and continental Europe, were made wholly or partly of a single hollowed log or half log. Many hull forms were used and the vessels varied in size although in medieval England they were generally under 6m long (Chapt.5).

HYBRID SYSTEMS OF CONSTRUCTION.

Dugout elements were used until recently in combination with carvel and clinker systems (Chapt.6). Planking laid as in the carvel manner could also be used with clinker laid planking as in the Bremen cog of c.1380 (Kiedel and Schnall 1985).

2/ THE DEVELOPMENT OF MEDIEVAL BOAT ARCHAEOLOGY: An historical survey

The following survey focuses on nautical archaeological finds and early synthetic works up to the initiation of this study at the end of the 1980's. The most recent syntheses bearing on the study (McGrail 1993, Hutchinson 1994, Marsden 1994, 1996, and Crumlin-Pedersen 1997) are briefly surveyed at the end of this chapter as they have emerged during the course of the study and have not substantially altered its focus or results, although they have provided more comparative material. However, aspects of these works and details of the new Magor Pill find, also recently published, (Nayling et al 1998) are referred to where relevant.

2/1 SOME FORMATIVE EARLY 19TH CENTURY WORK.

The period 1820 to about 1860 saw the birth of a systematic interest in the nautical past of medieval northern Europe. Before then there was no accumulated corpus of data to refer to. However, in the 19th century, antiquaries still had the opportunity to watch traditional boatbuilders and users at first hand. Some realised that this experience was of value for interpreting ancient boat finds, though it was diluted by popular history and the hegemony in things maritime of the Vikings.

2/1/1 THE ROTHER FIND.

In 1820 a substantial vessel was found in a silted up course of the estuary of the Rother in East Sussex, and was described in some detail by W.Rice (Fenwick 1978 and fig.5). The vessel was clinker built of oak, about 19.4m long with a beam of about 4.57m. It was described as being caulked with moss and the frames were treenailed to the planking. The bluff, 'flat floored' hull resembled 19th century Dutch coasting vessels with which Rice was familiar. Despite the almost familiar Low Counties appearance, the heavy burthensome hull the vessel was inevitably linked to the 'Vikings' in the contemporary public mind. The remains were destroyed in the 19^{th} century.

2/1/1 THE ASHBY DELL FIND.

In 1830 a boat was unearthed in NE Suffolk. Local estate carpenters visited the site and some of their remarks concerning the boat were recorded (Green 1963). The vessel was very different to the Rother vessel though it was still clinker built. The planking was identified as 'riven larch' (split-out *Larix decidua*) at the time. However, it was more likely to have been another softwood such as pine (*Pinus sylvestris*) as larch is a central European tree not planted in England before the 17th century (Edlin 1975:169). A significant feature of this vessel's construction was that it was sewn or lashed together, rather than fastened with iron or wood. This vessel has been seen as possibly very ancient, though an alternative might be that it derived more recently from Northern Norway. There Saami boatbuilders produced sewn, softwood, clinker boats, one of which might possibly have ended up on the east coast of England after prolonged N.E. gales.

2/1/3 WALTHAMSTOW 1 BOAT.

Also in 1830 the remains of a clinker built boat were found in an old course of the river Lea in NE London, during excavations for a reservoir (Fenwick 1978). The vessel was recorded as being about 6.10m long with a beam of about 1.84m and a depth' of about 0.46m. Little record was made of this find, though it was apparently luted with cowhair and 'cement' (Fenwick 1978:188).

In sum it is possible to say that before the 1860s, there could not have been an archaeological framework into which to put any particular individual find. Though popular feelings tended to associate these finds with the Vikings.

2/2 MORE METHODICAL RECORDING OF DARK AGE AND MEDIEVAL BOAT FINDS BEGINS- 1860S TO 1913.

Considerable development took place in this period with the realisation of the importance of recording, details and more general features of excavated boat finds.

2/2/1 THE SNAPE BOAT

In 1862 a barrow in Suffolk was opened under the supervision of the antiquarian Davidson. Rows of what were recognised as clinker-boat rivets or 'rove nails' were revealed and the faint impression of a large boat recognised. Though the interpretation of the find as a boat burial was remarkable for the period the records made were lacking in any detail. The sketch made clearly shows a boat with a squared-off stern. Associated finds dated the burial to the Early Anglo-Saxon period.

This find has been subject to a re-examination by Fenwick who has shown that the recorded shape is inconsistent, both as to the flat bottom and squared off stern (Fenwick ed. 1978:193). All well preserved clinker boats of the early medieval period that have been found so far have been pointed at both ends ('double ended'). Apart from in small dugout craft, squared off transom or counter sterns are rare until the very end of the medieval period. Rare exceptions include the 12th century Egernsund 'barge' from SE. Denmark which has up swept ends that would appear square in plan (fig. 6. Crumlin-Pedersen 1997:300, Finderup 1996).

In sum, we know that this Snape find was that it was clinker built with iron riveted laps ('lands') and was recorded as being about 14m long with a beam of about 3m.

2/2/2 THE NYDAM OAK BOAT

The excavation and recording of parts of three large clinker boats deposited as bog offerings was carried out under the supervision of C. Engelhardt in 1863 (Rieck and Crumlin-Pedersen 1988:103). This work can fairly be described as the first reasonably methodical excavation of a boat find in NW Europe. Despite the fourth century date before the focus period of this study there are two other reasons for regarding this group of finds as pivotally important. Firstly, they were made in an area archaeologically and historically associated with the Angles. Secondly, the Nydam oak boat has been taken as a principle 'ancestor' of the great clinker galleys or ‘long ships’ of later periods.

The near complete 'oak boat' was the best preserved find (fig.7), though parts of another oak boat and some timbers of a softwood vessel were also found. The oak boat was so well preserved that a physical reconstruction was carried out and comprehensive detailed drawings made of it. The vessel was about 23.5m long with a beam of 3.05m, though the reconstructed beam and freeboard is much debated (Rieck and Crumlin-Pedersen 1988:116). Most of the strakes of the hull were thought to have been in one piece and therefore exceptionally long boards. However, it is still possible to see in the restored vessel that in some strakes the angle of emergent knots, once branches (tilted slightly upward. in oak) reverses indicating the scarfing of at least two separate boards for those strakes. The laps were fastened with iron rivets or 'rove nails'. The naturally grown, single piece frame timbers were lashed to cleats left up-standing on the insides of the hull boards. The keel was very wide and shallow.

The immaculate, though 'sanitised' drawings of Magnus Petersen show a long lean, open clinker built galley pointed at both ends and steered with a quarter rudder. The association of the weapons suggested that the vessel was a warship.

2/2/3 THE TUNE SHIP.

In 1867 the first major Viking ship burial was excavated in SE Norway. However, this vessel, known as the 'Tune ship' was far less well preserved than the Gokstad ship excavated a few years later. It is more relevant to deal with the Gokstad ship for this study as its legacy as a nautical type fossil has been far greater (below).

2/2/4 A FRAGMENTARY FIND FROM THE RIVER USK S.E. WALES.

In 1878 workmen digging a timber pond near the mouth of the Usk revealed part of the side of a clinker boat (Morgan 1878). This was the first fragmentary boat find, of medieval date, that appears to have been published in the archaeological literature, the find and contemporary comment is usefully reviewed by Hutchinson (Hutchinson 1984). The most important aspect of this find is that it appears to have consisted of a slab of articulated oak clinker boards reused as shuttering in a simple stake and plank river or dock wall, the most common mode of reuse of such material. Morgan appears to have had some knowledge of boats and noted the presence of treenail holes, corroded iron rove nails, the species of timber- oak and also luting of 'dark coloured wool' (Morgan 1878:403). He enlisted the help of the 'dockmaster' and a local shipwright in further examination. They were able to spot evidence of the past presence of 'ribs', and together they suggested that the oak was 'Danzitic' oak (SE Baltic, probably due to particularly slow and even growth) and the parent vessel was probably built in that area.

Morgan then linked the find to medieval accounts of Viking raids in the area in 893AD and described it as 'Danish'. Coincidentally a recent C14 date, for the one surviving board fragment, of ad 950 +/-80 falls rather close to the assumed date of Morgan (Hutchinson 1984:27).

2/2/5 THE GOKSTAD SHIP

In 1880 a very well preserved clinker ship was found in a burial mound in SE Norway (Christensen 1986). The vessel was about 24m long with a beam of about 6.25m. The associated finds of this prestigious burial were recognised as of Viking date, perhaps of around 900AD. The hull was double ended, almost entirely of oak, with a protuberant keel and sharp uprising ends (figs.9,8). It was equipped to be propelled both by many oars and sail.

Several interesting details of construction were recorded many of which survived in the vernacular coastal boats of many parts of W Norway up until recently such as, the use of two short lengths of curved timber ('lot') vertically scarfed to join the keel and the stems for and aft. The cleft and hewn oak hull boards were joined end to end with short through-splayed scarfs, and all the plank laps and scarfs were fastened with iron rove nails. The edges of the hull planking and many other timbers were marked with shallow mouldings. The composite frames included cross beams with integral knees at alternate ends ('bitr', fig.9). These features are now seen as typical of Scandinavian shipwrightry at this period.

There are also archaic features resembling constructional methods used in the Nydam boat, the U-shaped oak floor timbers were lashed to lugs left upstanding on the plank surfaces. Differences included the use of lots, (fig.10) and oar ports cut through upper hull planks rather than working from fulcrums on the gunwhale.

The vessel was equipped with a strong keelson for a mast of about 25 cm dia. showing the importance of sail and oars for propulsion. The rudder was slung on the starboard ('steerboard') quarter as in the Nydam Oak boat.

Importantly the remains of several small boats were found within the ship and reconstructed they show the variety of sizes contemporary boatbuilders produced in that area, for high status users. Significantly the frame timbers of these lightly built craft were fastened directly to the hull boards with wooden pegs with swollen outboard ends and wedged inboard ends (headed treenails, fig.92).

In sum, this ship was recognised as a prestigious vessel and rapidly became the stereotypical 'Viking ship'. The standard of craftsmanship and volume of labour that went into her was much appreciated by nautical men of Norway. So much so that a replica, the 'Viking' was built and sailed across the Atlantic in 1892 as an ambassador of Scandinavian commerce and industry (Christensen 1986).

However, the building methods were those used in a large yard of the period rather than a practical investigation of the methods of her builders.

2/2/6 THE WALTHAMSTOW DUGOUT

In 1900 a dugout 'canoe' was found during civil engineering work along the course of the R. Lea, E. London, which resembles other more recent finds from the area including the Clapton dugout boat (Chapt.5). The Clapton boat is tree-ring dated to the late 10th century (Tyers 1989). Unfortunately little record was made at the time of this earlier find but, as usual, it was thought prehistoric because it was 'primitive' (Fenwick 1978 here fig.11).

2/2/7 THE WALTHAMSTOW No.2 BOAT

A clinker built boat was also found in 1900 close by. Fenwick has subjected the small but mysterious literature on this find to critical analysis which is briefly summarised here. Some photographs and measurements were made at the time. The boat was found capsized in an old channel of the R. Lea, beneath 1.65m of silt. It was described as having been about 14m long with a beam of about 2.15m. At one time it was thought to be associated with a Viking sword, but Fenwick has clearly demonstrated the erroneous and romantic nature of the connection. The boat is now thought to have been post-medieval, possibly 16th century, in date (Fenwick 1978:192).

The planking was set in a rabbet of the broad shallow keel plank which was described as elm . The planks were about 0.3m wide and 25mm thick, with iron lap rivets spaced at about 11 cm centres. Treenails were used to fasten the 'joggled' frame elements to the planking. The inside of the bottom of the hull was fitted with a ceiling of wide closely fitting planks, which are shown on a contemporary photograph (Fenwick 1978:fig.2). In sum, this vessel appears to have been some form of flat-floored, clinker river barge.

2/2/8 THE OSEBERG SHIP

This vessel was found in 1905 in a burial mound south of Oslo, the rich associated grave goods were clearly Viking, and probably 9th century. Now the vessel is known to have been deposited in the summer of 834AD due to the tree-ring dating of the burial chamber timbers (Bonde and Christensen 1993:581). In terms of its construction this vessel was similar to the Gokstad ship but rather more lightly built. The lower hull below and near the presumed water-line, was joined to the upper hull sides with a wale strake of complex shape, which gives a chine at this point (figs. 12,9). The hull was also shallower and must have operated with less 'freeboard' than the more seaworthy Gokstad ship. The degree to which the hull of this vessel was ornately carved distinguishes it from all other Viking period ship and boat finds. The ship was always thought to have been a high status craft in which much highly skilled labour had been invested, perhaps something akin to a royal barge.

2/2/9 THE WOOLWICH SHIP

During excavations, in 1912, for a power station at Woolwich on the south side of the Thames, just east of London, the relatively intact lower hull of a carvel built ship was found. It was lying in a silted up inlet or dock (Salisbury 1961, for the most complete account, of what is generally though to have been the remains of the ship ‘Sovereign’). Although the vessel was largely destroyed by the contractors officers of the London County Council were eventually able to make some annotated drawings and take some photographs of parts of the hull, building on their success in recording the Roman County Hall ship a year previously. Salisbury describes in some detail the events surrounding the discovery of the wreck, and why it was not thoroughly recorded when first uncovered. Eventually, in 1914, the admiralty were encouraged to set up a committee to consider the matter. By this time all that remained of the important ship were a few scraps of timber and some stone cannon shot!

From the assembled records, a crude description of this early carvel built vessel can be drawn together (fig.13) and it can now be dated to around 1500AD on the basis of the associated pottery (Redknap 1984). Apart from the radically different construction system this vessel was also vastly larger than any craft mentioned earlier. Salisbury estimates, using 16th century shipbuilding sources, that the ship may have been 115-120 feet on the keel (perhaps 135' in total?), though the vessel's beam is more difficult to reconstruct. The hull was rounded in cross section with a shallow protruding keel and high dead rise.

The hull has been considered carvel built in a similar manner to many wooden vessels of the early 20th century, frames first. However, we should note here that the lack of fastenings between the floors and futtocks indicates that the vessel was probably built shell-first at least in the lower hull (fig. 3). We now know this was common in many early N.W. European carvel ships particularly in the Low Countries (Maarleveld 1994).

No clear scantling table has been reconstructed for this ship find but the following can be deduced. The frame timbers of grown oak were wider than they were deep and some had traces of notches or 'joggles' left from an original use in a clinker built vessel. Recent work by Adams has shown that the frame timbers almost certainly came from another ship broken up partially for the building of the Sovereign (J. Adams Pers Com.). Very little iron was used to fasten the vessel together the frames were held to the planking with 11/2" oak treenails. Most of the lower hull planking seams were covered with battens as a waterproofing aid, as the builders did not apparently fully trust their caulking methods.

The internal structure of the hull was also very different to that of earlier medieval clinker craft. Inside the frames a ceiling or 'sealing' had been laid, on top of which a second tier of heavy frames or 'risers' had been fastened. The keel was also doubled up with an additional for and aft timber running over the floors but under the risers, the keelson.

2/2/10 THE THIRTIES: THE VISTA OF MEDIEVAL SHIPBUILDING BROADENS

Several important finds of previously unknown types of medieval vessels were made in the 1930's and more details of construction recorded, moving the subject forward. The key finds directly relevant to this study are outlined below

2/2/11 THE UTRECHT SHIP

In 1930, during the digging of a canal, the remains of a well preserved vessel were found in a silted up water course in Utrecht, the Netherlands. The form and construction of the vessel was recognised as ancient, and it was initially dated to between AD 1 and 1000 by reference to the deposits in which it lay (Vlek 1987:1). It was put into local museum cellars where it could be visited after conservation, and reassembly. A brief report and two reconstruction models were produced within four years although technical details and the interpretation and dating of the find have remained contentious ever since and it is currently subject again to a detailed reappraisal (A. Van de Moortel Pers Com.).

The boat is rounded in cross section and had a gently rising sheer (fig.14), and a length of about 17 m, a beam of about 3.6m and a depth midships of about 1.3m. The most distinctive feature is the enormous dugout bottom supported by grown oak ribs treenailed to it and extended at the ends by two scarved and treenailed timbers. The sides were raised with three strakes of oak, fastened clinker fashion with willow treenails secured with oak wedges, and including a 'D' section wale. The laps were waterproofed with moss held in place with laths on the inside secured with iron staples or 'sintels'. This later feature is recognised as a marker of low countries boat and ship building at this period (7/3 below). River cargo vessel is now the function commonly ascribed to this vessel (eg. Greenhill 1976:191). Some workers also see the dugout based vessel as being a form of 'hulc' ('Proto-hulc') ship as denoted by some documentary sources (eg. Ellmers 1972:59).

2/2/12 THE KALMAR FLEET OF VIKING TO POST-MEDIEVAL VESSELS

A complete review of all the Kalmar ship and boat find reports would not be appropriate here or even all the details of the ship and boat building recorded but a selection of the evidence is discussed below. During the early 1930'ties many vessels and fragmentary finds were made when the old area of Kalmar harbour, SE Sweden was dredged. Remarkably, fairly detailed drawings were made of all of them, photographs taken and notes made of technical details such as the shape of joints and fastenings. Unfortunately little of the material was conserved.

This work is the largest single project and contribution to medieval ship archaeology that we have yet seen in N.W.Europe. The results were published in detail in 1951 by Akerlund, and set standards for such work at that time. Two vessels are singled out here as particularly significant for this study as they provide key comparative material, the No.1 and No.3 boats.

2/2/13 THE KALMAR NO1. BOAT

This vessel, found in 1932, was particularly well preserved so that it has become almost a standard for comparison for many other medieval craft. It was recognised immediately as a small trading vessel about 11m long with a beam of 4.55m, the hull was fuller ended and much deeper, at 2m, than any of the earlier medieval vessels described here so far (fig.15). It also had a much less bold sheer. The stern post was straight and equipped with a central rudder rather than a quarter rudder. The keel protruded slightly below the bottom of the hull.

The hull was clinker built, principally of oak, with the laps fastened with iron rove nails, though some treenails were also used. The grown oak frames were held to the plank shell with treenails, and considerable strength added athwart-ships with a three tier system of beams. The heads of some of the beams passed through the hull planking. At the time of the excavation there was very little comparative evidence to draw upon. Akerlund found medieval seal representations which showed this detail of construction.

Akerlund was very thorough indeed and discovered a drawing of a similar reused ships beam excavated on a medieval land site in Skanor in 1907-9 (Akerlund 1951:44). This was an early use of the potential of fragmentary or reused nautical timbers to expand and extend the corpus of material based on relatively rare wreck finds. There was a keelson and widely spaced stringers fastened to the inside of the frame elements to add longitudinal strength and support the cargo. Loose decking of 'furu' (*Pinus sp*?) was found in the bow and stern of the vessel.

No evidence for the use of oars as a main aid to sail propulsion was found. Even an anchor was recovered. Using the few small finds recovered and a large study of the seal evidence Akerlund dated this find to about 1300, which is broadly accepted today.

2/2/14 THE KALMAR NO.3 BOAT

The detailed publication and analysis of this vessel represented an early example of the serious investigation of a small planked boat. The clinker boat was very well preserved but was found in a dislocated condition, although the suppleness of the timber allowed it to be physically reconstructed, photographed and drawn.

The boat was 4.4m long with a beam of 1.53m. It had a slightly hollowed oak keel plank to which curved after and fore stems were joined with a simple birds mouth joint (fig. 16). Stem and stern post were pierced for rope attachment. The oak planking was up to about 0.3m wide and 15mm thick, each strake being made up of two or three short boards scarfed together, the laps were fastened with iron nails. The hull was supported by 3 grown oak ribs, joggled to fit the planking and fastened with oak treenails. Two horizontal breast hooks were also fitted, timbers which were not used in the earlier medieval finds described up until now.

The gunwhale was given a heavy capping timber to resist the chafeing of gear being repeatedly pulled over it. This last feature together with the size and form of the boat was interpreted as suggesting that Kalmar No3 was a small fishing boat or a tender to a larger vessel. Interestingly other 'new' features were also recorded, such as pairs of pegs for oar fulcrums ('thole pins'). Akerlund suggested that this feature, and indeed the boat, was of medieval date (Akerlund 1951:56) by comparison with a seal dated to 1357. However, the close dating of the find is by no means secure. Another feature anticipating recent practice was the fitting of a 6cm deep false keel of pine below the keel plank. This had the effect of producing shallow 'T' shaped keel out of two separate pieces of timber, whereas in the earlier medieval vessels the keel was hewn in one piece. Unfortunately the details of how the planking was converted in both the No.1 and No.3 boats were not published, but the proportions and shape of the boards used in Kalmar 3 suggest the use of thin cleft boards (Chapt.7 below).

Though details were no doubt different, in general appearance and construction the vessel would appear to closely resemble the early representations of the small Thames fishing boats called 'Peter boats' (eg. in Hollar's 17th century riverscapes of the Thames). Kalmar No3 can therefore stand as a standard for comparison for small, later medieval clinker boat finds from NW Europe.

2/2/15 THE BURSLEDON SHIP

Moving to the other end of the size spectrum for medieval craft, in 1933 a reconnaissance of a large vessel, just visible at very low tides was made in the Hamble river, SE England (Andersen 1934). Only a brief report is relevant here as the remains lie largely unexcavated (fig.17). Despite this limited level of investigation a unique system of construction was found in this 15th century vessel. The hull skin was made up of 3 layers of short, cleft oak, boards laid in a curious version of clinker construction. This strange innovation was interpreted as an attempt to strengthen a very large, and potentially over stressed, shell-built clinker hull. It was the subject of a brief display at the National Maritime Museum, following visits to the site by members of staff. Some notes have also been published more recently on the find but they are thrown in to doubt by a failure to consider modern disturbance (Goodburn 1993b).

2/2/16 THE ARBY BOAT

In 1935 a well preserved Viking period small boat find was made in central Sweden (Arbman 1940). The vessel was built of oak and pine and was about 4m long. It had dugout keel plank with two clinker laid strakes added to it and fastened with iron rove nails. It was recognised as essentially a small, light personal transport boat for lake use. In fact it is the smallest planked craft to be reviewed here, the vast majority of early medieval vessels of this size appear to have been dugout boats of various types (chapts,5 and 6).

2/2/17 THE LADBY SHIP

This 10th century burial ship impression was found on Fyn, Denmark in 1935. It is important here because it was the subject of the first really, controlled systematic, excavation of a decayed ship impression (Thrane 1987). The hull had iron riveted laps, and was 'double ended'. It was also long and narrow 20.6m with a beam of only 2.9m (Greenhill 1976:214). More recently it has been subject to a detailed reappraisal and a new accurate model and publication have been produced (Bischoff and Jensen 2001).

2/2/18 WORK AT SUTTON HOO IN 1938 TO 1939

The smaller vessel

The archaeological work carried out on the two early Anglo-Saxon ship burials at Sutton Hoo has been published in very considerable detail so that only the briefest outline is presented here. In 1938 B. Brown carried out an excavation of the smaller ship burial mound at this famous site in east Suffolk. Though apparently not aware of the work carried out at Ladby 3 years earlier he quickly recognised the presence of a decayed ship impression because of his knowledge of the Snape find (Bruce-Mitford 1975). The main diagnostic detail seems to have been the presence of iron rove nails, showing that the vessel was clinker built.

Although Brown was a highly skilled excavator (popularly known as the 'shipwright of the earth ship' referring to his work on the larger ship impression) his recording was extremely sketchy, fortunately his interpretation of the hull as being square ended has now been rejected as counter to everything we know about the development of the ship, at this time. Brown's opinion of the shape of the original vessel was no doubt coloured by the form of the local 20th century clinker vessels which had varieties of transom stern. Green showed later the square end was inaccurately understood (Green 1963:55). The vessel appears to have had a length of about 6.7m and a beam of about 2m.

The investigation of the larger ship impression

In 1939 Brown called in specialised help, moved on to mound 1 and skilfully exposed the bulk of what has been called the largest Germanic ship burial ever found.

The ship impression was comparatively well recorded for the time and a brief account published by C.W. Phillips which included a draft of the ship's shape (Phillips 1940). The shape recovered was double ended but included strangely distorted upper ends, as the effects of collapse had not been fully accounted for. The impression was that of a very large clinker built open boat, or ship, about 27m long with a beam of about 4.6m. The laps and plank scarfs were fastened with iron rove nails, though it was not clear how the frame elements were fastened. In general terms, it is important to note that the 'Northman's longship' had now firmly crossed the North Sea and appeared in the archaeology of early

Anglo-Saxon England. The rich assemblage of grave goods, was dated to the 7th century.

2/2/19 TWO SYNTHETIC WORKS PUBLISHED IN THE EARLY 1940'S AND 50'S

The corpus of knowledge of dark age to early post-medieval ship and boat archaeology had grown by this time to the extent that synthetic works could be written. Though these works are largely ignored by workers in the field today they mark an important stage in the development of the sub-discipline.

Brogger and Shetelig's 'Viking ships, their ancestry and evolution' provides a detailed consideration of early Scandinavian ship finds laid out in an evolutionary scheme (Brogger and Shetelig 1951).

They concluded that Viking ships probably evolved from skin covered craft thought to be depicted on prehistoric rock engravings. This view has been effectively rejected by Crumlin-Pedersen and others (Crumlin-Pedersen 1970) who argue that expanded dugouts were probably the technological precursors to the late Iron Age ancestors of the 'Viking boats'.

More interestingly the two authors concluded that the Viking ships, such as the Oseberg ship, were built on pre-erected frames in the manner of recent carvel shipbuilding in Norway and elsewhere. This inversion of what we know through detailed examination of clinker boat finds in recent times is difficult to understand. In Norway particularly, in the west and north, clinker boatbuilding in a tradition very close to that of the Viking age was still a comparative 'common place' in the early 20th century. In a sense, all that the two authors had to do to understand basic principals of construction of clinker vessels of the Viking period was to visit some traditional west or north Norwegian small boat builders. Presumably the fact that they did not take craft practice seriously reflected the social distance between 'historians' and traditional craftsmen.

2/2/20 BOATS AND BOATMEN

Other works of much wider scope based principally on ethnographic study, such as Hornell's valuable 'Water Transport' could be briefly discussed here but their focus is arguably too broad, although constructional details were often noted (Hornell 1946). Instead a different type of work is considered. Though written by a, once well known, English archaeologist it is one seldom now used. Lethbridge's 'Boats and Boatmen' is an idiosyncratic synthesis constructed out of personal observation of recent traditional boat use, historical generalisation and a background of general archaeological knowledge (Lethbridge 1952). A few points and trends in his arguments are relevant here.

He discusses some aspects of the evolution of boatbuilding technology and traditions of hull shape in terms of the established diffusionist mode of thought that was dominant at that time. The protruding keel for example he thought a classical idea borrowed by the northern barbarians. He also prepared a schematic 'family tree' of the evolution of the boat with plank built boats derived from dugout boat in a series of steps largely unsupported by the evidence existing then (Lethbridge 1952:12-13).

Some of his discussion reached the level of a consideration of shipwrights tools. He wrote:

> 'The shipwrights trade was born as a result of one implement, the adze'. (Lethbridge 1952:14).

It would appear that this statement was based on his observations of recent British practice where the adze was the principal hewing tool, no ancient evidence of its predominance is cited. However, he was fairly clear about the basic construction principles of shell-built clinker and skeleton-first carvel boat building as a result of watching recent traditional boat builders at work.

There are three areas where Lethbridge's approach is particularly interesting from a point of view of the theory of boat archaeology. Firstly, he stressed the economic role of boats in fishing and trade and suggested that study of their use in the past was worthy of much more attention. Secondly he went into considerable detail about the wider social role of boats and their use, through a discussion of related ritual and magic. Thirdly, he touched on the symbolic role of boats through a discussion of terms used for parts of boats and how these mirror terms for parts of the human body. His approach clearly saw recent boats and their uses as parts of ancient continuing traditions (3/3/5 below).

2/2/21 THE KENTMERE EXTENDED DUGOUT BOAT

An important find was made in a silted-up mere in Cumbria, NW England in 1955. The find was fairly well preserved and some archaeological recording was made in-situ by D. Wilson and others, who published a brief interim account of the boat (Wilson 1966, fig.19 here). The dismantled boat is held in store at the NMM and was re-examined in detail for this study (Chapt.6). Only a brief outline is provided here.

The boat was published as 4.25m long and is what is now often called an 'extended dugout' with the ends and bottom half of the flat bottomed hull hewn out of a single oak trunk and the sides extended with five very narrow, clinker strakes aside.

Fortunately Wilson realised the importance of the find as a rare example of a hull between dugout boats and fully planked craft in form and it was C14 dated to around 1300AD (Wilson 1966:81). Importantly he suggested in the synthetic section of his report that many small dugout finds were likely to be of medieval date and that they constituted an important part of the water transport of the period. At the time this was quite an iconoclastic suggestion that challenged the common assumption that such boats were so primitive that they must be prehistoric.

2/2/22 MODERN APPROACHES TO MEDIEVAL BOAT ARCHAEOLOGY START TO TAKE SHAPE, THE VIKING PERIOD FLEET AT SKULDELEV DENMARK

The excavation and study of these vessels, sunk to form a navigational barrier in the 11th century, has had an enormous impact on medieval boat archaeology. A detailed interim report was produced in 1968 from which time the body of material has been used for comparison by workers in the field (Olsen and Crumlin-Pedersen 1968).

The initial investigation of the vessels took place under water followed by the building of a coffer-dam and a systematic 'dry' excavation. At first it was thought that there were the remains of six wrecks, though later work showed that there were large parts of five vessels in total . The flattened out ship structures were skilfully lifted and drawn at 1:1 for accuracy and to aid in the conservation and reconstruction of the hulls (Olsen and Crumlin-Pedersen 1978:75, Append 8). The approach to recording these nautical timbers was more methodical than had been used on any prior project. Novel methods were also used to the display of the finds. The timbers were remoulded, after conservation by immersion in PEG., using heat to increase plasticity and installed in a black armature of steel representing the near original shape of the vessel concerned.

Aspects of these finds and research that they have engendered have been extensively published elsewhere and will be referred to throughout this study but it is important to note a few key points here. Several different types and sizes of vessel are represented and have now been taken to demonstrate the spectrum of large and medium sized clinker built vessels of the late Viking period (fig.20).

Most important of all for expanding horizons in medieval boat archaeology are the two broader, deeper craft which were soon interpreted as trading vessels rather than 'Long ships'. The smaller No.3 Boat, was built of oak and was

13.8m long with a beam of 3.4m and a depth of 1.3m amidships. The hull boards were mainly of radially cleft oak, with some longer examples tangentially cleft and hewn. The framing was very carefully hewn and fitted, not fastened to the keel and incorporated frequent bitr. The frame to board fastenings were headed willow treenails (Wagner 1986:133).

This vessel was seen as 'eminently suited for sailing in the Baltic and North sea' (Olsen and Crumlin-Pedersen 1978:114). The boat was not equipped to be rowed in more than auxiliary capacity unlike the long ship finds discussed earlier. Various reconstructions have been built of the craft, the building of the most authentic *Roar Ege* has been an open air experiment of great worth and has informed this study considerably (Andersen et al 1997).

The larger No.1 boat was between 16-17m long with a beam of 4.5m and was quickly interpreted as deep sea trading vessel. The other 3 vessels are of less interest in terms of how they have radically broadened our view of Viking seagoing ships. The Nos' 2 and 5 are considered as long ships. The No.6 boat has not been allocated to any clear function though fishing boat has been suggested.

Constructionally the Skuldelev fleet varied in detail considerably but one major feature stands out, the frame elements were fastened to the planking with treenails headed outboard and wedged inboard. Lashings were not used as in the lower hulls of some earlier vessels. Iron rove nails were the main fastenings of laps and scarfs but were not well preserved. Toolmarks were well preserved on some of the timbers and Olsen and Crumlin-Pedersen were able to show that axes were the principal hewing tools not adzes. No evidence of the use of saws was found. The hewn planking was sometimes smoothed further using scraping tools not planes as would be use by recent boatbuilders. Marking-out lines were also recorded. The variety of finish and timber used in the vessels was taken to indicate origins out side Denmark at least for the largely pine No.1 boat (Olsen and Crumlin-Pedersen 1978:116, here fig.21). Systematic botanical analysis of the internal structures of the vessels have shown how in some of the craft surprising species of low rot resistance were used such as, alder, willow and linden (Wagner 1986). The shape and availability timber was clearly more important than the species in some cases. It was also noted that several phases of repair and even the reuse of second hand shipboards could be seen. More recently extensive tree-ring analysis of the finds has been carried out showing them to be of 11th century date and their probable regions of origin (Bonde and Crumlin-Pedersen 1990).

2/2/23 THE BREMEN KOG: EVIDENCE OF A DIFFERENT STRAND OF NW EUROPEAN SHIPWRIGHTRY

This famous find of a large vessel, tree-ring dated to about 1380, was made in 1962 during dredging work in the R. Weser, N.W Germany. The very well preserved ship was quickly recognised as a probable cog ('kog', 'kogge') such as were otherwise known only from documents and seal representations. For the first time a Hanseatic trading ship had been found to give solid form to earlier speculations. It has been displayed reconstructed and undergoing conservation for many years (Append 6).

The vessel can not be dealt with here in detail but key points are noted below. The ship is large 23.5m long with a beam of 7m and depth of side of over 3m amidships (fig. 22). The hull is significantly different to those of the craft discussed up to now. The stern is pointed but straight with a centre line rudder, whilst the bow is also straight and raked. The middle 2/3rds of the vessel is flat floored but with rounded bilges, the overall impression is of a comparatively bluff vessel built for bulk cargo transport.

A review published in 1985 contains considerable information about its construction. The find typifies developments in later medieval shipbuilding technology. The hull planking is of wide sawn oak planks and most of the other timbers in the vessel were hewn, sometimes rather more roughly than in many earlier craft (Lahn 1985). The middle of the lowest section of planking is laid edge to edge and only permanently fastened to the floor timbers. All the frame to plank fastenings were oak treenails. Lahn writes that all the joints and 'dowels' (treenails} were tarred before assembly. The vast majority of the planking was however, laid clinker fashion fastened with twice turned iron nails, sometimes a feature taken as a principal characteristic of cog construction (Ellmers 1985). The laps were water proofed with moss held down with a lath on the inside, the lath in turn being fastened with iron staple-like 'sintels'. The keel and end posts were joined with a distinctive crooked oak knee-like timber. Lastly the sides of the vessel were tied together with through beams similar to those of Kalmar No.3. The above characteristics have now been taken by some as a suite of attributes which enable the name cog to be applied to a ship find. Reinders has discussed many recent Dutch Ijsselmeer polder finds as being varieties of cog so defined and has drawn together a summary of some cog building techniques (fig. 23, Reinders 1985). Other low countries workers have also added usefully to the corpus of evidence on cog building (eg. Van de Moortel 1991).

2/2/24 THE RE-INVESTIGATION OF THE LARGE SUTTON HOO SHIP BURIAL

The many grey areas left after the initial investigations in 1939 were deemed to require checking by the mid 1960's through the application of very careful, systematic, modern recording (Bruce-Mitford 1975). Though the ship impression had suffered much disturbance in the intervening 27 years new information about the ships hull shape was obtained and some details of construction clarified. The hull was now seen as a 'normal' double ender, the keel was found to be flanged and shallowly protruding. Though the evidence could never be absolutely clear, the frames were recorded as having been fastened to the hull with treenails and the lap fastenings were found to be round shanked iron rove nails (fig.24).

2/2/25 THE BLACKFRIARS NO2. BOAT

This find was made, with a three others of different dates, when a narrow strip of the river Thames was won in the western part of the City of London, between 1962 and 1970 (Marsden 1972). The rescue excavations were very difficult and resources limited. The fragmentary boat find, now known as the Blackfriars No.2

boat was found partly exposed in a coffer dam. The in situ records made are rather ambiguous, but Marsden was able to retrieve some disturbed timbers from the wreck and record those in some detail (Marsden 1972). These timbers were principally light oak frame elements cut to fit the clinker hull of the boat. Marsden was able to graphically reconstruct the unusual construction of the hull (fig.25). This shows a broad shallow elm keel plank and a skin of thin 15mm (3/8") thick oak clinker planking iron riveted (rather than treenailed) to slender oak floor timbers. Two layers of softwood planking were fastened down over the floors and some rider knees placed over the internal double skin. This system of construction is completely without parallel and will be examined in a future study. The key features of note here are the use of distinctive new materials in English boatbuilding such as sawn imported softwood sealing planking. However, as the 17th century find lies just outside this study's time-frame it is cited for contrast only. Marsden reconstructed the vessel as long and lean with a length of about 14m and a beam, of the preserved bottom only, of at least 2m. He saw the brick cargo as defining its use as a river barge (Marsden 1972:97).

2/2/26 THE BLACKFRIARS BOATS Nos 3 AND 4

In 1970 a largely complete clinker built vessel was found in the same land winning project little to the east of the No.2 boat. Fragments of another, the No.4 boat, were also found (Marsden 1972). Both finds were considered to be of late 15th century date initially but have been redated by tree-ring analysis to the late 14th century (Tyers 1996a). The No 3 boat still remains the most complete late medieval boat find from Britain, baring the Bursledon ship, and is also now a useful standard against which to offer up London's more recent fragmentary finds following its detailed reinvestigation (Marsden 1996:55).

The boat was thought to have been about 16m long with a beam of 3m (Marsden 1972:130) and was flat floored, round bilged and double ended (fig.26). The laps were fastened with iron rove nails and the frame timbers with treenails. The vessel was equipped with a mast step and is interpreted as a river barge, or 'shoute' (or 'showt' Spencer 1996:210) as they were called on the Thames at this time. It appears to have sunk with a stone cargo.

2/2/27 THE GRAVENEY BOAT

In 1970 a drainage contractor exposed part of a clinker vessel of oak which he quickly realised was ancient. The vessel lay in a silted-up creek running off the estuarine R. Swale, N Kent. After the excavation of the contents of the wreck by the local archaeological group the British and National Maritime Museums carried out a rapid but careful excavation of the hull itself (Fenwick 1972 and 1978 ed., fig.27). The hull was dismantled and recorded at 1:1 by McKee in great detail (Append.8), followed by careful modelling to reconstruct its probable original shape.

The first report, published in 1972, was packed with technical details such as; the hooked form of the hood ends, and the form of the headed willow or poplar treenails. The vessel was immediately seen as something new in the then existing corpus of boat finds from NW Europe. Newly found features included the broad, shallow plank keel and massive, crudely shaped frame elements (fig.27). The broad and heavy construction clearly indicated a cargo carrying function, and probable traces of an in-filled mast step were found.

Strangely one of the principal excavators initially wrote that:

> '..there is no reason to assume that she was built in England.' (Fenwick 1972:128).

This view was inverted in the final report where otherwise unparalleled constructional features were suggested to be indicative of early English boatbuilding (Fenwick ed. 1978:251). The research on this vessel helped inaugurate the Archaeological Research Centre at Greenwich which from the mid 70ties to late 80ties contributed to the establishment of the 'Archaeology of the

Boat' as a respectable area of study in England. Sadly it was disbanded in the late 1980's.

The multi-disciplinary report produced in 1978 is a landmark in the development of medieval boat archaeology in Europe and in many respects set a standard for full publication only very recently equalled in some respects (eg Crumlin-Pedersen 1997, on the Hedeby finds and in many areas Nayling et al 1998 on the Magor Pill boat). The Graveney vessel emerged from investigation and reconstruction by Mckee, at about 14m long with a beam of 3m. The hull form was double ended with straight raking stem and stern posts and flat floors with rounded bilges amidships. Minimum and maximum interpretations of the vessels function were offered from a lighter to a coastal or short sea trader. The work of the team lead to the following realisation:

> 'Our object must be not only to record the shape of the hull in-situ but also the tiny details of construction, upon which the study of ancient boats will increasingly focus'. (Fenwick 1972a:178).

The work has been of great assistance in this study.

2/2/28 CUSTOMS HOUSE BOAT TIMBERS: INCLUDING A LARGE REUSED HULL SLAB

During rescue excavations that kicked-off systematic waterfront archaeology in London at Customs House in 1973 large sections of articulated planking from a medium sized clinker boat were found. They had been reused as sheathing in a river wall (Tatton-Brown 1975 and fig. 28). A clinker frame timber was also found reused as a post. The structures were dated by associated finds to c. 13th century (now known to be late 12th date, Tyers 1996a) in . The sections of hull side were the most complete remains of a large boat of the 12th to mid 14th centuries known from England until very recently (Goodburn 1988, 1991a, Nayling et al 1998). The elevation drawing done in situ (fig.28) was fairly detailed but has recently been up-dated (Marsden 1996:41).

2/2/29 THE NEW FRESH WHARF (NFW74) BOAT TIMBERS, AND 'SLAVONIC' BOATBUILDING IN SE ENGLAND?

In 1974 rescue excavations on the City of London waterfront produced reused clinker boat timbers initially dated to the late 9th century. Articulated boards of oak and a few frame elements were recovered (Miller 1977). The lap and frame to plank fastenings were both bulbous headed treenails and the luting moss, for some time these fragments were without close parallel in finds made in England. At first the possibility of a 'Slavonic' origin was suggested on the basis of parallels with finds from the SE Baltic. But many other finds now show that NFW74 style lap treenails and moss luting were widely used in SE England from at least the late 8th century (Goodburn 1987, 1994a etc.).

2/2/30 THE MEDIEVAL SHIPS OF LONDON

This was the title of a brief review of the medieval nautical material excavated in London, published by Marsden in 1979 and re-worked in 1981 (Marsden 1979 and 81). In it lists, sketches and photographs predominate with little detailed information. The New Fresh wharf fragments are briefly described as above and a possible exotic eastern origin suggested, though local origins were not ruled out. By 1981 the treenails had been identified as willow secured with oak wedges. The Customs House planking slabs were interpreted as having been derived from '..a fairly small double ended clinker built vessel...' (Marsden, 1979:86). In many respects the lack of solid information about the ship and boat building practice behind these finds inspired the later part of this study.

2/2/31 A PERIOD OF SYNTHESIS OF THE NEW AND OLD DATA 1976 TO 1987

The volume of work up to the 11 year span of 1976-87 was sufficient to inspire new syntheses more solidly based on archaeological evidence than before: several key works are surveyed below. Greenhill's 'Archaeology of The Boat' published in 1976, has several main themes of interest here. Firstly, he was strong proponent of the 'Living Tradition' approach to boat archaeological research, in which vernacular boatbuilding is seen as a major source for understanding the boatbuilding of ancient periods. Indeed, he starts the book with a description of several recent traditional small boat types and spends much of the rest of the book exploring the complexities of their technological 'ancestry'.

He emphasised the concepts of 'shell-first' and 'skeleton-first' building, systems and their development. More specific details of ancient boat and ship construction were also described and illustrated with the help of other NMM staff (eg. fig. 29). The introduction of carvel shipbuilding to northern Europe was covered and linked to the world girdling development of the ocean going three masted ship. This book is still inspirational and encouraged some lines of enquiry in this study (see 1/1 above).

2/2/32 LOGBOATS OF ENGLAND AND WALES

McGrail produced this extensive work in 1978 as a doctoral thesis, which has many strands of relevance here. The first is simply as a valuable corpus of dugout boat finds which include many medieval and Saxon examples. Secondly the study attempted to demonstrate the varied nature of dugout boats ('logboats') and show that their study could be productive. It also included a brief and discussion of the evidence for the techniques of construction of dugout craft drawn, mainly from ethnographic sources rather than from the dugout boat finds themselves. Following the work of Rackham on medieval carpentry and the selection of trees used for it(1972, 1976), attempts were made to reconstruct the 'parent trees' used to build some of the boats. However, the lack of practical experience of building dugout boats resulted in some misleading reconstructions of the raw materials used (see Chapt. 5 below).

2/2/33 THE BRYGGEN BOAT AND SHIP TIMBERS REPORT

Between 1955 and 1968 many reused and dumped boat and ship timbers were found during excavations on the site of the Hanseatic warehouses in Bergen, W Norway. A period of several years study of this material by Christensen revealed that almost all parts of clinker vessels from early medieval to early post-medieval date had been recovered (Christensen 1985). His report was the first detailed account of reused medieval ship and boat timbers compiled. The very extensive report on this material, contains tabulated information on similar elements, fragments of boards, frame timbers, fittings, and beams for example. Several framing elements from a very large medieval clinker ship (the 'Big Ship') were excavated and threw light on the post-Viking construction of clinker see-going trading craft (fig.30).

In addition to the corpus the work also had a useful synthesis on new light on Norwegian clinker building practice of considerable use here for this study. Christensen discusses tools and yard practice in the synthetic sections of the work (Christensen 1985:197-255), with deep practical understanding. The complex factors effecting the introduction of sawn boat planking in Norway are dealt with. Many working procedures are reconstructed in detail by reference to the finds themselves, and Christensen's familiarity with vernacular west and north Norwegian boatbuilding. The importance of comparatively numerous fragmentary boat finds as reservoirs of information about boat and ship building through time was clearly demonstrated for the first time in this work. The Big Ship for example appears to be larger than any contemporary wreck find in the region.

2/2/34 PROGRESS IN MEDIEVAL BOAT AND SHIP ARCHAEOLOGY FROM A DANISH PERSPECTIVE DURING THE 1980'S

Crumlin-Pedersen and his co-workers in Denmark made many contributions to this field during the 1980's which saw a flowering of high quality reconstruction projects and the compilation of a number of synthetic papers. A brief over view is provided here and many of the papers are referred to later in the study where appropriate. Crumlin-Pedersen's review of the changes that took place between the Viking period and later medieval times 'From Viking Ships to Hanseatic Cogs' is valuable for contrasting late Viking cargo vessels with the later cogs and clinker 'keels' (Crumlin-Pedersen 1983, fig.31). The paper showed that some of the later medieval vessels built in the 'Nordic' tradition were as capacious as many cog finds. It also showed how some constructional features were adopted from one building tradition to another.

In key papers in 1986 early use was made of insights gained through serious experimental reconstruction work (Crumlin-Pedersen 1986a, 1986b,). Areas of ship and boat building practice covered included the cleaving of radially cleft shipboard, the parent log numbers and sizes required and aspects of tool use. His team also hosted a valuable symposium on experimental boat archaeology published in 1986, which included many relevant papers for this study on tools and raw materials (Crumlin-Pedersen and Vinner eds. 1986 eg. Wagner 1986, Christensen 1986 etc.). The application of tree-ring studies to some of the Danish material also started to yield some surprising results such as the discovery of high quality Irish oak in the Skuldelev 2 ship of c.1060AD (Bonde and Crumlin-Pedersen 1990). As some of the samples came from the large cumbersome keelson timber not just the boards which could be more easily traded, it seems that the vessel had an Irish origin.

2/2/35 REUSED FRAGMENTS AT HARTLEPOOL

In 1982 a modest rescue archaeology project in part of Hartlepool's (NE England) medieval port area revealed some reused medieval boat fragments (Young 1987). The small archaeological unit was the first to publish a substantive report on fragmentary boat finds, in Britain. Small fragments of cleft oak, iron riveted clinker boat planking had been reused as vertical fendering in a stone dock.

2/2/36 WHAT OF EVIDENCE FROM SOUTH OF THE ENGLISH COASTS?

Northern France

The medieval boat and ship building traditions of our nearest continental neighbours in Northern France and Belgium are relatively little known due to an apparent lack of finds and lack of detailed publication of what has been found. One partial exception is the L'Aber Wrac'h wreck found on an inlet in the North coast of Brittany and partially investigated by the DRASM (French National Underwater Archaeology Service, L'Hour and Veyrat 1989 Append. 6). The wreck is dated by associated finds to the 15th century. Very importantly it is clinker built with cleft oak boards though found in an area where all the local vessels have been carvel built for at least 150 years and probably much longer.

The vessel was a heavily constructed cargo carrier over 25m long and thus may have been built some distance from where it was found, perhaps England or Normandy (or possibly English colonies in SW France?) where well established clinker boat and ship building traditions either existed or are likely to have existed. Indeed documentary sources investigated suggested that the vessel might be an English ship that sank in 1435 (Veyrat and L'Hour 1989:298). A radially cleft hull board seen in 1988 by this author could certainly be exchanged with London examples (Append.6). The laps were fastened with large iron rove nails and the frame timbers with treenails. The oak frames were made in five pieces with a floor and 1st and 2nd futtocks on both sides, some use was also made of protruding cross beams. The outboard ends of these beams were protected with tapering chocks of 'elm and alder'. The keel was apparently of beech.

One is forced to the conclusion that this vessel might well have been an English ship according to the evidence presented, though, curiously, this possibility is not accepted by the authors of the brief preliminary report. Some attempts at tree-ring sourcing her timber have been made, but as yet no dates or provenance have been found (I.Tyers Pers Com.).

New work currently underway on medieval clinker ship remains found off the Guernsey coast will soon start to yield valuable information but the work is only at the survey stage to date (J. Adams Pers Comm.)

Western France

Further SW in France some detailed and systematic work by Rieth has shown the existence of distinct regional styles of construction. These appear to bear no clear relationship to those of England, even though England was essentially part of western France in political terms for the middle of our period under the Angevin kings. In the river Charente the remains of a flat bottomed, double ended craft were found and recorded (Rieth 1994). The planks and carved bottom to side transition planks or 'ile' were rabetted together and fastened to cross and knee frames. The system of construction is currently without clear parallels.

Very recently Rieth has also been able to present an interim report on the unusually preserved remains of the upper parts of a capsized vessel, Port-Berteau II, from the lower Charente (Rieth 2000). The construction of the vessel is also extremely unusual with a form of flush laid planking which appears to be some form of carvel construction with cleft and hewn planks and thicker wale strakes. From the published evidence first presented in 1997 at ISBSA 8 at Gdansk it is not clear weather the vessel was built frame or skeleton first. Through beams were fitted for and aft and the ends appear to have raised platforms, whilst the middle is an open hold. It is suggested that the craft was probably a small coastal trader. It is dated to 5th to 8th AD by C 14 methods but tree-ring samples will be measured to tighten the dating. The author also notes that many medieval dugout boats have also been found in the same river system dating from the 6th to 13th centuries AD.

2/2/37 'ANCIENT BOATS IN N.W. EUROPE' A RECENT SYNTHESIS

A wide ranging account of 'Ancient Boats in N.W. Europe' was published by McGrail in 1987 which is essential reading for any student of the subject (McGrail 1987). The book is constructed in themes rather than around place or period, and in so doing reflects the continuity of many aspects of boat and ship building and use. Large sections of the work are devoted to boat and ship building technology with sub-headings such as 'felling trees' or 'shaping strakes' (the structure of Chapt. 7 is partly based on its format). There is by way of introduction a chapter on the classification in which a flow diagram is used to represent categories of boat defined on form grounds (fig.32). However, it is not clear to this writer what extra insight we gain from this form of classification; this criticism will be expanded upon in chapter 3. Despite lacking some practical detail the summaries of evidence for woodworking practice and tools in the nautical field is referred to throughout this work . In sum, this work contributes to the backdrop for the study of medieval English boat and ship building practice presented here.

NOTE- The new finds and synthesis works noted below were published when this study was well underway and although none of the publications has substantially altered the general strategy and approach used for this study, much new parallel material is now available. Some of this new evidence has been drawn on where appropriate below. It is also the case that some interim summary publications by this writer have been drawn upon to some extent by some of the following workers in the field. In other cases lines of enquiry already adopted for this study such as, the systematic reconstruction of parent trees used by boat and ship builders or ancillary workers (Goodburn 1991b, 1992b etc.), have been experimented with in some of the following with varying degrees of plausibility.

2/2/38 THE FRAGMENTARY DUBLIN CORPUS

The publication of the large corpus of fragmentary boat and ship finds from Dublin provided much directly comparable material to the body of London medieval nautical finds (McGrail 1993). Several themes were explored to attempt to maximise the evidence that can be gained from the study of fragmentary medieval nautical timbers, such as the probable size category and possible functional type of the parent vessels. To attempt this work more complete finds from Scandinavia were the 'type fossils' used such as the Skuldelev 3. Indeed the connections of boat and ship building evidence with the 'Viking/Norse' tradition was stressed, perhaps somewhat exclusively as Dublin and its region was part of the Anglo-Norman world from the mid 12th century. Indeed, close parallels with some of the contemporary London evidence can be seen with the later finds, whilst clear parallels with Scandinavian evidence such as multiple strake ends are undeniable in the earlier material.

Efforts were also made to investigate some of the themes central to this study such as the conversion of timber for the ship and boat building and toolmark evidence. However, these were hampered by the somewhat dried out condition of much of the material and conservation requirements. Some information was also recorded about methods of repair.

2/2/39 THE LONDON MEDIEVAL CORPUS UP DATED TO 1989 AND EXPANDED

The earlier published summaries of several relevant London vessel finds such as the New Fresh Wharf material and Blackfriars 3 barge were up-dated and expanded in the publication of the two companion volumes, Ships Of The Port Of

London First to eleventh centuries and Twelfth to seventeenth centuries (Marsden 1994, 96). The new publications provided clear illustrations (by Caldwell) of much of the material for the first time, and included a large selection of fragmentary reused nautical woodwork from excavations in the historic London suburb of Southwark. Some of this later material was initially recorded by this writer. The two main themes of the studies were to provide an overview of the evidence for changes in the types of boats and ships that used the historic port, and to provide some insights into the possible performance of the craft. Details of changes in boat and ship building practice were not key foci and virtually no tool mark evidence was systematically recorded, neither were parent trees reconstructed.

Contributions by other Museum of London staff at the time were of considerable importance such as the extensive tree-ring analysis by Tyers, and the collection of documentary evidence for ship and boat building work and individual shipwrights in medieval London (Tyers 1994b, 1996, Dyson 1996, and Spencer 1996). These two sources are drawn upon and critically reviewed through out the following study. A key omission of the later corpus were the large number of carvel ship timbers in the form of planking, wales and framing excavated on the Southwark sites from which the clinker vessel timbers described in the report were drawn (Goodburn 1996a Un Pub). The corpus therefore under represents the work of shipbuilders working in the new carvel style in the 16th century.

2/2/40 MEDIEVAL ENGLISH SHIP AND BOAT ARCHAEOLOGY IN A WIDER SETTING

As the quantity of archaeological information for medieval ships and boats in England began to accrue so did information on medieval ports, quays, trading patterns and fishing. The need was clearly there to set the boat and ship finds made in England or off the English coast in a wider historical, economic and social setting. That is to merge boat archaeology with maritime archaeology and history in their broadest guises. This was achieved by Hutchinson a useful review drawn on in several places for this work (Hutchinson 1994).

2/2/41 FRAGMENTARY AND PARTIALLY COMPLETE BOAT AND SHIP FINDS FROM THE HEDEBY REGION: MOVING A SYSTEMATIC APPROACH FORWARD

Well along the course of this study in 1997 a large body of evidence from the Hedeby and Schleswig region, now in the NW corner of Germany (but during the Viking period in Denmark) was published by Crumlin-Pedersen and his co-workers (Crumlin-Pedersen 1997). This study was both a detailed study of three main clinker ship finds of the Viking period found in Hedeby's harbour (which are on display and have been briefly examined by this writer Append. 6) and also a major corpus of other fragmentary and more complete boat and ship finds from the wider region. The more complete planked vessel finds covered include, the Hedeby, 1, 2, and 3 wrecks the earlier Gredstedbro vessel, the Schuby-Strand vessel and the flat bottomed punt-like Egernsund ferry. Before completing a description of the three main finds Crumlin-Pedersen sets the geo-historical scene and summarises developments in the archaeological study of ships and boats in northern Europe up to the mid 1990's. The port town of Hedeby is placed at a frontier location between four different ethnic and pollitical groupings the Danes, the Saxons, the West Slavs and the Frisians. During the study Crumlin-Pedersen shows evidence of technical features of the finds such as the nature of the fastenings, which appear to have ethnic associations. For example the use of treenail fastenings is predominantly seen as a typical feature of W Slav clinker boatbuilding although the possibility of the fastening method also being used by the Saxons is alluded to due to the examples that have been found in England (Crumlin-Pedersen 1997:123). Indeed, the detailed study of the very varied treenail fastenings considered by the project may have shown that evidence of the origin or function of even fragmentary nautical timbers may be gleaned through investigation of the wooden fastenings. This would parallel such studies of iron fastenings by Bill and others (Bill 1994). We might just add the cautionary note here that in Saxo-Norman London similar headed treenails were used in both land and nautical work (see below, and Goodburn 1992a:128).

One of the most interesting areas of the study for this writer was that on 'Selection of wood for shipbuilding' where the ecological environment of the region is considered as the three main vessels appear to have been built fairly locally from the tree-ring analysis. Importantly the land uses of timber are also considered as much of the town and harbour were waterlogged and the excavated non nautical woodwork has been studied and characterised. It is shown that the ship and boat builders of the region may have faced some shortages of the very largest high quality trees for board cleaving, and have reused materials and used less durable species such as beech. Paradoxically it is also shown that the very largest and most finely made radially cleft oak clinker ship boards known from Viking period were found in the Hedeby wreck 1.

Wreck 1 consisted of the articulated remains of substantial parts of the lower hull of a very large long ship tree-ring dated to around 985 AD. It is estimated that the vessel was probably 26-32 m long! The vessel was very lightly and carefully built using elaborately scarfed boards up to 10.2m long. The great size of the vessel, very high quality long boards and quality of workmanship are taken as likely indicators of Royal ownership.

Wreck 2 is a complete contrast with No.1 in that it is a much smaller and less carefully built vessel. It had a very curious hybrid form of clinker construction with an oak boarded lower hull fastened with iron rove nails which was extended upward with one beech strake followed by several of pine fastened with lap treenails. It is suggested that this may have been a Saxon or W Slav vessel shown to have been built fairly locally in the late 10th century through the tree-ring analysis.

Wreck 3 was largely dismantled by a diver and was studied as a collection of framing timbers including floors, cross beams and a keelson together with a few oak plank fragments. It was convincingly shown to have resembled the Skuldelev 1 larger cargo vessel. The tree-ring study showed that it had many oak elements with over 300 rings which were high quality timbers dating to felling in 1025, relatively locally. However, the extensive wood species identifications carried out for the study showed that timber of very surprising species had been used for some of the framing including ash, alder, and maple (Crumlin-Pedersen 1997:104). The explanation proffered is that the immediate region had an unusual shortage of grown oak timbers but no explanation for this curious state of affairs is offered.

Importantly for this writer detailed studies by Hirte of two Viking period dugout boats are also included together with a corpus of regional dugout boat finds. The two small dugout boats, one of beech the other of oak share some characteristic with the broadly contemporary Clapton dugout boat discussed below (Chapt. 5). The point is well made that the most common small boats of the Viking age have been found to be dugout vessels often showing much variation (Hirte 1997:148, Chapts 5 and 9/2). A useful survey of the toolmark evidence is made but strangely no comparison was made with the well documented toolmark study of the broadly contemporary Clapton boat which was published 8 years earlier (Goodburn in Marsden 1989 ed.).

A whole fleet of new early and later planked vessel finds was made recently when the Roskilde Viking Ship Museum was expanded and interim notes have appeared on some of the finds (Myrhoj and Gotche 1997). The new finds will enrich and extend the information gained from the study of both the Hedeby and Skuldelev ships, and also shed some more light on changes in Scandinavian clinker ship construction from the late Viking period to the 14th century. However, they will not be considered further here due to a lack of detailed information and their very recent discovery.

2/2/42 THE SEVERN ESTUARY TRADER OF 1240 AD FOUND AT MAGOR PILL

Many of the advances made in boat archaeology recording and analysis were effectively, systematically and very rapidly employed in this study and publication of the remains of a small clinker built coastal trading vessel (Nayling et al 1998). The standards of illustration of all items were similar to those of the Graveney project but details such as toolmarks and the presence of tree anatomical features were recorded far more clearly. Indeed there was also a brief toolmark survey carried out by Brunning showing that a variety of axes had been used as the primary tools in building the vessel. Another area where the quality of the record was impressive was in the noting of setting-out marks for the fitting of frame elements and hull board scarf cutting etc. Indeed the quality of the presented record is such that some technological aspects can be reinterpreted in the light of practical experience and knowledge of other collections of broadly contemporary material and a few of these are noted below. The contributors fairly recognised that the study did not cover all areas of possible investigation but made the range of high quality evidence widely available in a well ordered form.

Very thorough tree-ring sampling programmes were carried out both of the radially split oak hull boards and oak framing elements as well as the radially split beech 'sealing' boards. The work provided not just a date for the construction of the vessel of early in 1240 AD and showed the beech sealing was original but matches to regional chronologies were also attempted by Nayling and Tyers. Interestingly the tree-ring sourcing evidence shows very high matches indeed to the chronologies for the broadly contemporary Gloucester Blackfriars roof timbers which are well documented as coming from the large area of dense woodland just to the west of Gloucester, the Forest of Dean. The Magor Pill boat mean and Gloucester priory mean match with a 'T' value of 11.7. Indeed in the case of one of the parent trees reconstructed an extraordinarily high 'T' value of 19.36 was recorded with the same mean (Nayling in Nayling at al 1998:121). These suggestive matches were not discussed in the report but suggest to this writer that a likely place of building was on the banks of the Severn close to the forest of Dean. The interesting fact that some of the framing and boards appear to come from the same parent oak may also imply building near the site of felling for logistical reasons. Some of the issues raised by this work are revisited below.

2/2/43 THE GRAND CORPUS OF DUGOUT BOATS OF CENTRAL EUROPE INCLUDING FINDS FROM BRITAIN

Arnold's Volume 1 provides a very clearly illustrated temporal over view of very varied dugout boats from much of Europe from later prehistoric to recent times (Arnold 1995). This corpus includes brief entries on a large number of medieval English examples such as the Giggleswick Tarn, Clapton boats and Kentmere extended dugout. To some extent the corpus assembled shows patterns of variation linked to the availability of particular tree species and types of treeland. In another superbly illustrated follow up work (Vol. 2, Arnold 1996) themes such as hull forms and the section of the tree used are addressed with illustrated glossaries. There are also clear presentations of the tool mark evidence in cases of well preserved examples which must be seen as standard setting in some respects. The tracing of large zones of facets to some extent captures the original flow of the finishing axe and adze work and takes us closer to the builders. Systematic approaches to tree-ring dating dugout boat finds are also demonstrated.

3/ THEORETICAL 'SCHOOLS' IN BOAT ARCHAEOLOGY: Towards a theoretical basis for this study

Introduction

The literature survey (Chapt.2) has attempted to summarise the development of medieval nautical archaeology in northern Europe up to the mid 1990's with little discussion of it's theoretical underpinnings. However, several loose 'schools' can now be recognised, though workers in the field frequently eclectically combine aspects of more than one approach in any particular study, as will be the case here. The following brief descriptions in chapter 3/ part 1 are not seen as rigid categories but convenient foci for discussion. Chapter 3/ part 2 outlines the synthesis of various approaches developed for this study.

3/1/1 THE 'NEW' BOAT ARCHAEOLOGY SCHOOL

This approach is defined here as concentrating on the systematic, statistical study of; features of boat and ship structure, characteristics of hull form and the performance of vessels. The initial aim was to provide an easily computerised, hierarchical scheme of the evolution of vessel types and constructional features.

Features of construction and hull form have sometimes been abstracted to 'attributes' denoted by letters and numbers (fig.32). McGrail has been the principal exponent of this laboratory based, nautical architectural approach and could, for example, describe an extended dugout boat, like the Kentmere 1 (Chapt. 6) as a 'C4' (McGrail 1987:8). Ship and boat archaeology has clearly benefited greatly from the insistence on systematic work and quantification of data that this school advocates but this approach, in it's extreme form, does not deal adequately with the people and societies involved in the story. It fails to situate boats and ships and their builders in their social, economic, cultural and environmental location. Neither does the approach appear to seek any explanatory power so that, the essential questions of why boat and ship builders do particular things or change ways of working are not addressed. Details of vessel construction are also treated as fragmented technical features rather than part of a complex, practical and cultural system.

3/1/2 THE ENVIRONMENTAL-DETERMINIST SCHOOL

Most workers in the field make use of environmental data in interpreting the mode of use of ancient boats and ships. The degree of importance given to environmental factors in shaping boat and ship building varies greatly. It was Mckee who developed this theme to its greatest extent in his 'Working Boats of Britain' (Mckee 1983). Here he laid out, in detail, the working environments of various local types of traditional boats around Britain, the sea and wind conditions etc. His principal concern was with the form of boat hulls rather than the details of their construction (which however, he also keenly observed). He developed a hull form typology into which British traditional hulls would fit. Though eclectic use was made of other approaches, the following quote highlights what he saw as the principal factor effecting the specific nature of a particular boat type:

> 'Like wild plants certain sorts of boats tend to favour particular surroundings... so one starts by looking at the sea and shore the cobles had to use.'

A coble is a distinctive type of traditional English fishing boat (Mckee 1978:1). This approach fails to explain why boats used for similar purposes, in similar, environments in proximity to each other, at the same time, are often so very different! Clearly many other factors are also thinly covered in this approach, such as the history and traditional working practices of the builders or their social position. The availability and economics of the supply of materials is also an underrated area in this approach.

3/1/3 PARADIGMS OF BOAT AND MARITIME ARCHAEOLOGY

Attempts have been made to classify and locate the archaeology of boats and ships within archaeology as a whole, by Muckelroy, amongst others (Muckelroy 1978). This work was principally concerned with defining the limits and role of nautical archaeology, its paradigm, but it also contributed more specifically to areas such as understanding wreck formation processes.

3/1/4 THE ETHNO-HISTORICAL SCHOOL

Nearly all nautical archaeologists make some effort to ascribe the material they study to particular historically known groups of people, Vikings, Slavs or German merchants or Basque fishermen for example. Sometimes this is conceived of in explicitly ethnic terms such as, 'Nordic', 'Slav' or 'Celtic'. Boatbuilding traditions are seen as having been invented by one ethnic group and to be capable of being adopted by others, frequently after military conquest. Ellmers was a leading exponant of this approach, attempting to fit boat finds to historically known ethnic groups (Ellmers 1969). Much attention has also been focused on ethnicity in boatbuilding by Marsden and Crumlin-Pedersen (Marsden 1979:86, Crumlin-Pedersen 1985a).

Whilst the issue of the visibility of ethnicity in boatbuilding is clearly very important, most of this work has been based on assumptions which the increasing quantity of excavated evidence seems to contradict or at the very least greatly complicate. For an example relevant to the London situation we could cite the debate over a so-called 'Slavic' attribute (Marsden 1979:86, Crumlin-Pedersen 1997:98) of early medieval clinker boatbuilding- fastening laps with treenails and luting them with moss. This can now be seen to have been too narrowly defined. The system of fastening and waterproofing was widely used in Saxon period boat finds made in SE England and in modified form in the Low Countries. In neither region do we have evidence of the existence of emigre Slav boatbuilding communities (Goodburn 1986, 1987, 1994a). Indeed, Crumlin-Pedersen is now able to reappraise the ethnic and historical location of this attribute and suggest that it may well be a Saxon (or North Germanic) characteristic taken to England during the migration period (Crumlin-Pedersen 1997:123). This writer suspects economic conditions and the local cost of iron may also be important factors in some regions where mixed approaches may be found, sometimes even in the same vessel such as the Hedeby 2 wreck (Crumlin-Pedersen 1979:96).

The practical effects of the ethnic attribution of aspects of maritime culture in understandings of English maritime history and archaeology for the early medieval period

Here we come up against the 'Viking' domination of the early medieval north European maritime world in popular and even non specialist archaeological consciousness. In England the pre-eminence given to the Vikings as seafarers and boat builders reaches such proportions that any clinker built vessel is often described in the nautical press as 'showing its Viking origins' even though we know clinker built craft were being built in England as least as early as the late 6th century AD. Smolarek has described some manifestations of this approach at it's crudest as the 'Viking psychosis' where all clinker built finds are automatically labelled 'Viking' (Smolarek 1985:422). Although many of the other ethnic and political groupings of early medieval Europe have little of the Holywood embellished glamour of the Vikings we have good evidence of them being effective seafarers. The waters around England were traversed by the craft of many non 'Viking' peoples such as the Frisians, Anglo-Saxons, Franks and many Celtic groups. However, it is fair to say that much less effort has gone into researching the boatbuilding traditions of all these other groups than those of the Scandinavian kingdoms. This is partly a straightforward result of accidents of preservation, with several areas of Scandinavia having ideal conditions for the preservation of nautical remains from this period (such as the fjord barrage at Skudelev) but it is also the result of a lack of academic and institutional focus in many cases. The academic establishments of countries to the south and west of Scandinavia have not held the boat archaeology of this period in the esteem it is held in Denmark (which leads in this respect) and research centres and dedicated

Museum collections have not been set up with equivalent rigour. For example, a considerable number of relatively complete vessels from the early (and later) medieval period are on public display in Scandinavia at sites such as the Viking Ship Museum at Roskilde. Many high quality full scale reconstructions of vessels of the period can also be seen. By contrast the only relatively intact Viking period planked vessel find from England, the Graveney Boat is not on display and there is no information available in the region of the find spot or at any of the local museums! But in the same county of Kent a completely speculative Viking ship reconstruction has been on open air public display at Pegwell bay for decades.

At the Museum of London a display case in the early medieval gallery has some nautical archaeological content and even though several small Anglo-Saxon ship board fragments are on display the large backdrop painting is based on a classic stylised 'Viking' vessel! Although to keep the record straight, (as this writer works part time for that institution) a small amount of boat archaeological woodwork of the period was displayed coherently in a modest temporary display recently entitled 'King Alfred's London'. The reused ship elements included Anglo-Saxon treenail fastened and iron fastened shipboards and small fragments of a Low Countries' or Frisian vessel that was broken up in 10th century London. Thus, the non specialist view of the boats and ships of the early medieval period is slowly beginning to reflect the hard archaeological and historical evidence but the symbolic hegemony of the 'Vikings' is still very powerful. A secondary aim of this study has been to examine the evidence for traditions of planked vessel construction that were distinct from those of Viking period Scandinavian dominated areas as well as those of 'Viking' type (Goodburn 1994a provides a brief summary).

3/1/5 THE LIVING TRADITION SCHOOL

Several workers in the field of boat archaeology and ethnography have described, in fairly explicit terms, how they believe recent vernacular techniques can sometimes be seen as continuations of ancient practices in some distinct regions and circumstances (Lethbridge 1952, Hasslof 1972, Christensen 1972). Whilst this approach shares some of the assumptions of that above it concentrates on the human dimension of the practice of boatbuilding as a cultural system. The focus is more holistic and the role of the ship and boat builders is set centre stage. For example, Christensen has written in great and perceptive detail about traditional W Norwegian boatbuilding practice and the ways in which boatbuilders learned their skills (Christensen 1972). The closeness of traditional clinker boat builders in that part of Scandinavia to practices of Viking period boat and ship builders is undeniable. Until the relatively recent campaigns of high quality experiments in medieval boat and ship building in Denmark took place (Andersen et al 1997) we could have had virtually no understanding of the role of axes as key tools of clinker boatbuilders with out the observations of Christensen and more recently some other workers (Christensen 1972, Gothche 1985). This is particularly true for British researchers coming from countries where traditional boatbuilders and shipwrights of the last hundred years frequently used relatively recent forms of adze but have had no knowledge of how to use axes. The mental toolkits of boatbuilders and the social organisation of yards are difficult to reconstruct from archaeological evidence alone but the slowly increasing corpus of high quality ethnographic accounts from Northern Europe provides essential parallels.

The idea that small traditional vessels often exemplify very ancient features and that any traditional wooden boatbuilder is working in a continuum of an evolving craft system is of clear utility to this author though the approach has been little used in Britain except by Greenhill (Greenhill 1976, Goodburn 1986).

3/1/6 THE EXPERIMENTAL AND RECONSTRUCTIONAL SCHOOL

Whilst nearly all nautical archaeologists attempt to reconstruct the vessels they study on paper or digitally and some attempt modelling at small scale, few have worked at full size. The meticulous and innovative modelling of the Graveney boat at 1:10 (by Mckee in Fenwick ed.1978) was of obvious value. The half scale modelling of the same vessel to produce a crewable sailing test bed is also of clear value (Gifford and Gifford 1995). But like all modelling efforts they both lack the depth of new understanding that working at full scale with authentic materials and tools can bring for students of the practice of boat and ship building. Some features possible in a model are impossible at full scale, such as building the hull on three long but low sleepers, that would block driving fastenings (a set up drawn by Mckee for the building yard of the Graveney boat). The importance of finding the correct raw materials to complete a reconstruction project to a high standard forces greater attention by those involved to documenting these aspects in the original archaeological finds. The issues of shipyard logistics and implied labour forces takes on new importance when the researcher must actually move that crooked green oak timber weighing half a tonne him or herself (Goodburn 1993c).

The clear leaders in the field of working at full scale with the original excavated timbers are Crumlin-Pedersen and his large team of colleagues who have reconstructed substantial parts of five flattened late Viking period craft (Olsen and Crumlin-Pedersen 1978). Useful insights into the logistics of cog building were gleaned in a similar way by Lahn during the reassembly of the original Bremen Cog (Lahn 1985). This type of work with conserved, original timbers and the detailed observations thus obtained about boatbuilding practice, has lead to serious experimental projects which have in themselves developed the subtlety of understanding of ancient techniques, skills and raw materials (Crumlin-Pedersen 1986a, 1986b, Andersen et al 1997 for examples). Indeed, the quality of work carried out by Andersen and others at Roskilde has been an inspiration and of great use in this study and it is cited at many points below. This level of authenticity of work contrasts with the very inappropriate use of totally anachronistic materials, techniques and tools in work in this field in England in the mid 1970's. The National Maritime Museum set out to build a reconstruction of the small four oared clinker boat found at Gokstad but the work failed to produce any new insights relevant to this study due to its lack of rigour in planning and execution (McKee 1974).

3/2 A NEW SYNTHESIS OF APPROACHES USED FOR THIS STUDY

Boat archaeology has developed far enough as a specialism within archaeology for the theoretical approaches used by researchers in the field to be explicitly stated rather than assumed. Section 2 of this chapter attempts to summarise a new synthesis of theoretical approaches developed to investigate boat and ship building practice across time, space and socio-economic distance. It is an explicit statement of the theoretical underpinnings of this study.

3/2/1 BOATS AS SOCIAL PRODUCTS

The approach taken here has grown out of the practical experience of this writer in traditional wooden boatbuilding, repair and restoration, field archaeology and academic training which involved some exposure to explicit use of theory in archaeology (eg. Shanks and Tilley 1987 etc). It centres on the explicit recognition that boats are SOCIAL PRODUCTS as much as any building, pottery vessel or brooch. The statement made by Childe about material culture in general;

> "As an archaeologist I deal with concrete material things ....I must treat my objects as concrete expressions and embodiments of human thoughts and ideas- in a word knowledge." (Childe 1936:27)

is taken here to apply to boats and indeed 'sherds' or fragments of boats. Boats, and arguably most ships, are given existence by particular social, economic, environmental and cultural energies, the comparative levels of which vary with time and place. Rudolphs' study of local traditional craft of the S.E. Baltic is a rare example of a study which seriously considers the social and economic correlates of features of boatbuilding (Rudolph 1974). He shows clearly how various types of construction can indicate the social position of the builders and users.

The cultural and social pressures which produced the elaborately carved elements of the Oseberg ship were clearly subsumed by utilitarian factors in the building of craft such as the Clapton dugout (Chapt.5) or the large Bremen cog though the reasons for this were clearly very different in each case. It is plain that boats and ships, and even quite small fragments of them, often carry subtle information about their builders, owners and users. This realisation was forced upon this writer when working on the restoration and rebuilding of recent vernacular wooden boats from various parts of Britain such as fishing craft Thames sailing barges, and clinker built workboat tenders. That type of work was typically carried out with a range of timber fastenings and surface finishes distinct from those used in similar work on yachts and naval small craft also undertaken by this writer. For example planking material might be local larch, elm or oak for a working vessel but more expensive Honduras mahogany or teak for a yacht or naval small craft. The fastenings used would also often vary on similar status lines with galvanised iron for the working vessels and more expensive bronze for the yachts and naval craft. During vernacular craft recording work this writer was able to find some extreme examples of this status-materials relationship in the use of cheap and generally frowned on beech in the bottoms of little known sailing barges used in 19th and early 20th century Chichester and Langstone harbours (Goodburn 1984). This timber is not recorded as a suitable nautical timber in England after the 18th century but was clearly still used for very cheaply built, low status gravel barges as late as the early 20th century in some cases. It appeared that similar distinctions should be visible in the material record of earlier periods and it was thus adopted as a research foci for this study (Goodburn 1986:43 and 1989:102, and below, with summary conclusions in Chapt. 9/1-9/3/1).

Very few other researchers in the field of boat archaeology have closely examined this area but recently Crumlin-Pedersen and co-researchers at Roskilde have considered this aspect worthy of rigorous comparative analysis for early medieval finds. For example, Crumlin-Pedersen has persuasively argued that the exceptional size and workmanship of the hull boards of the Hedeby 1 long ship indicate a likely royal status for the craft while the other two Hedeby vessels wrecks 2 and 3 represent two lower expressions of status Crumlin-Pedersen 1997:182-4). Hirte and Crumlin-Pedersen also suggest that the use of large oak logs was restricted for dugout boat builders who appear to have been forced to change over to the use of less suitable beech as timber supplies became more restricted. A rare effort to situate later medieval to 16th century boatbuilding in explicit social and economic circumstances has just been made by Bill for S Danish coastal vessel construction with interesting results running parallel to some of the results of this study (Bill 1997).

As social or cultural products, boat and shipbuilding traditions mirror the complexity of social, economic and cultural life in the sense that they are complex and can not be reduced to single or few identifying features (see Harris 1989 for related comments on the 'grammar' of medieval English carpentry). We can acknowledge this by considering many technical and subtle features of a nautical find before ascribing it to any particular category (Goodburn 1986). For example we might consider the degree of finishing of the timbers of a vessel as a mark of labour investment to be considered with other features such as the comparative qualities of raw materials used, not just the structural layout of its timbers.

3/2/2 THE CONSERVATIVE NATURE OF SHIPWRIGHTRY AND BOATBUILDING PRACTICE AND LANGUAGE

Another key consideration is that historic N European boatbuilding appears to be particularly conservative and exhibits many regional and archaic features. It is clear that traditional boats, often encode messages about past societies as well as those in which they exist. The same is clearly true of local boatbuilders' language. Vernacular craft terms in use into the 20th century often have medieval or earlier roots, related to the historical develoment of particular traditions of work (see Chapt.8). For example the term 'rung' or 'wrang' is sometimes used by traditional English boatbuilders where the standard nautical term is 'floor timber' (Append.1). This is commensurate with the 'wrong' and 'wrangen' of some English medieval texts (8/1/3). The replacement of real historical traditional terms with bland artificial archaeological jargon can hinder understanding and break the historical continuum which leads to a deeper understanding of material from the medieval period onward.

The concept of 'Living Tradition or boatbuilding traditions as part of a continuum rather than as static fossils is subscribed to here. However, we may still allow those who built and used the craft we study some capacity for innovation in changing social and economic conditions. A corollary of this is that both, more ancient and more recent boat finds and aspects of boatbuilding practice, may have the power to inform our analysis of any particular early historic finds. We can thus critically use ethnographic sources in constructing our interpretations of traces of ancient boat building. If such sources are as detailed as that provide by Osler in his study of Shetland traditional small boats they have great potential utility for nautical archaeologists (Osler 1983). First hand accounts of traditional boatbuilding apprenticeships, such as that by Frost in his rich and masterly 'From the Tree to the Sea' are also eye-opening sources (Frost 1985).

In a sense this writer sees part of the essential development of the archaeology of boat and ship building as one of academics becoming part-time shipwrights, both physically and mentally.

3/2/3 A RÔLE FOR SERIOUS EXPERIMENT

Alongside ethnographic sources we must put serious experimentation in the field of nautical technology. This writer follows Crumlin-Pedersen, Bill and others in using information and insights gained through high quality experimentation in ancient boatbuilding to develop new avenues of understanding of the original material (Crumlin-Pedersen 1986a, 1986b, 1997:86 etc., Bill and Johansson 1987).

First hand practical experience is essential for the 'forensic' reconstruction of the actual practices of historic shipwrightry, boatbuilding and ancillary trades in any detail. This statement applies to both, deepening understanding of the tools, techniques and labour used and also the nature of the raw materials and their sourcing. The experimentation must be penetrating and consider many or all the raw materials required and their individual harvesting and production rather than concentrate solely on the assembly of these harvested and often partially worked materials such as, timber, boards, wooden fastenings, iron nails, and tar. If this far reaching sort of perspective is taken the embededness of boat and ship building in particular societies becomes more apparent. The approach also ties boat archaeology to 'main stream' archaeology and history. Attempts to reconstruct workshop organisation and practice in human terms can be set on firmer foundations in this way, an ARCHAEOLOGY OF BOAT AND SHIPBUILDING WORK becomes attainable. The quantity and comparative quality of labour input can be suggested. Clearly, the role of work in the human experience of the past should not be ignored as it would appear to be what most people were engaged in most of the time during our period even if it lacks the glamour of war or a chieftains death rites.

An archaeology of work and workers in particular circumstances related to the nautical sphere is a key foci of this study. Boat archaeology that focuses on the structural lay out of timbers in finished vessels and their theoretical performance as its main concerns, can provide useful statistics but the ship and boat builders remain hidden. This study seeks to provide a view from on top of the pile of woodchips rather than from the admirals barge or the archaeological equivalent of the master shipwright's drafting room.

3/2/4 ENVIRONMENTAL RECONSTRUCTION FROM NAUTICAL TIMBERS

Another new area examined in detail in this study is the reconstruction of changing woodland resources used in the construction of test-case boat finds mainly from the London area. The method used to reconstruct the trees used to make ancient timbers and structures thereof is outlined in appendix 2. The pioneering work in this field was carried out outside the field of boat archaeology by Rackham in his study of selected standing medieval buildings (Rackham 1972, 1986a:42 etc.). Attempts have been made by a few nautical archaeologists to reconstruct the 'parent logs' from which timbers or whole boats might have been cut (McGrail 1978, Crumlin-Pedersen 1986a, 1986b, and Rival 1991). However, these efforts have not been carried through to reconstructing parent trees, varied treeland and woodmanship in detail (with the essential graphics), except in the outstanding case of Rival's work on selected classical period Mediterranean vessels. Although, some of the recent analysis of the Hedeby ships raw materials provides some subtle and interesting comparative information (Crumlin-Pedersen 1997:183, and table 1 here).

Woodmanship practices and other uses of the same treeland used by the boat and ship builders were not considered by most nautical specialist during the early phases of work for this study. This contrasted with studies of structural timber use on land by Rackham carried out as early as 1970 (Rackham 1972, 1986a:41). Similar wider views of this question were also derived later from work on land based early and later medieval structural woodwork such as the remains of quays, buildings, jetties and wells etc. (Goodburn 1992a, 1994, 1997b, 1998, 1999a etc). In the London region we are particularly fortunate to have a very large corpus of well recorded and sampled structural woodwork of all kinds from our study period c. 900 to 1600. In the vast majority of cases the thousands of written, drawn and photographic timber records provide information on the species and type of parent trees used to produce the timbers.

A supplement to these records of complete timbers are the results of studies of tree-ring samples both those viable for measuring and an often larger number documented but not measured. In some recent tree-ring analysis work on selected nautical timbers from finds of the c. 900 to 1600 AD period the tree-ring specialists have been frustrated in attempts to contribute to reconstructing changing tree land (Tyers 1996:197-8). This unfortunate state of affairs arose through a poor selection of samples and complete lack of access to suitable field records of the unsampled timbers in that case. Tree-ring specialists can not be expected to produce insights into treeland change working from a comparatively small set of samples isolated from the whole data set or at least high quality summaries of that information. It is now reassuring, towards the end of this study, that the importance of considering the nautical use of treeland resources and the non-nautical together have been recognised by at least one centre of research, Roskilde. In his analysis of varying timber use in the Hedeby wrecks, Crumlin-Pedersen also considered the general view derived from detailed studies of the land woodwork (Crumlin-Pedersen 1997:179). This work produced some parallel insights to those revealed in this study and they are cited below where appropriate. Interestingly the picture of changing SE English medieval woodland resources produced through the study of nautical woodwork differs somewhat from that produced through the study of 'land structural woodwork' (Chapt.9/5).

First hand experience of how certain species of trees grow, given a range of conditions, is essential for this type of research (Rackham 1976:Chapt.1, Goodburn 1991b). This task is easier in SE England than in many other regions of NW Europe as many pockets of ancient medieval-style woodland and other types of 'tree-land' survive for study today with the notable exception of wildwood (Goodburn 1992a, 1994b, 1998). The landscape is not dominated by relatively recent forestry plantations, or exclusive 'high forest' management. It is also important to note that other raw materials used for boat and ship building often require the use of woodland resources in their manufacture. An iron boat rivet or 'rove nail' for example is evidence for the work of the charcoal burners who made the fuel for smelting and forging, as much as it is of the 'clencher and holyer' (Friel 1986:41) who fitted it in the boatyard.

As much, if not most, of the land with trees on it was managed intensively during our period in SE England, we must also consider changing 'treescapes' as largely social products, just as were the boats and ships which were built from selected parts of them.

3/2/5 ENCODED LIFE HISTORIES

Given a detailed forensic approach to the recording and analysis of nautical woodwork it may be possible to suggest how a vessel was worn, repaired and/or refitted in its lifetime. This tells us something of the function of the craft and how that may have changed throughout its life (Olsen and Crumlin-Pedersen 1968:100 etc, Fenwick ed. 1978:100 Goodburn 1991a:111). It may even tell us something about the value the owners put on the vessel, or the lives of the crew! It may also tell us something of where a vessel has voyaged during its life time (Crumlin-Pedersen 1985b:218). This line of enquiry is in a sense the biography of an individual ship or boat find and is thus best included in a report dealing with an individual find. Therefore it is a theme explored in chapters 5 and 6 dealing principally with individual vessels but is dealt with rather more briefly in chapter 7 dealing with a thematic exploration of many vessels.

3/2/6 DEPOSITIONAL PATTERNS

The 'taphonomy' of a boat or ship and its constituent parts must be clearly tracked and understood if we are to realise how the archaeological material evidence is produced and what biases it is likely to have (Crumlin-Pedersen 1985b). Most of the evidence for ship and boat building in England from c.900-1600 has to be gleaned from fragmentary finds of reused timbers. Boat or ship 'sherds' can be compared with pottery sherds in that they form the bulk of the available material for archaeological study with relatively complete pottery vessels being scarce. The adaptation and selection procedures used by ancient woodworkers when they reused nautical timbers have to be explored to define the particular biases in the material for particular circumstances. The use of parts of vessels for fuel was probably also a factor determining which vessel remains survived to be incorporated in preserving contexts. This has been a key concern in recent times in the Thames Estuary region until the decades of widespread central heating. Many coastal areas in SE England have been relatively lacking in woodland but settlements in the coastal and estuarine marshlands still had a large need for fuel. This need for fuel must have resulted in the piecemeal destruction of many vessels along side the structural reuse of elements. It is also probably the case that the remains of small planked vessels were disproportionately destroyed in the fuel quest, and as they were less structurally useful it may be one reason why small planked craft are under represented in the corpus of excavated material. The types of sites where the material is or might be found also have to be considered. Chapter 4 of this work covers this subject in detail.

3/2/7 THE VISIBILITY OF RITUAL PRACTICES IN BOAT ARCHAEOLOGICAL MATERIAL

Some recent ethnographic studies and older historical works, taking a 'folkloric' approach to studying people and their boats have documented examples of the rituals which are common in boatbuilding in small scale societies (eg. Lethbridge 1952, Horridge 1986). These works act as an arsenal in the battle against crude functionalism which is commonly found in nautical archaeology. Even mundane technical details such as the choice of timber species used for a particular part of a vessel can be determined by established ritual rather than technical requirements or simple availability. For example, this writer was told in Scotland in the late 1970's, of the effects of using 'male' or 'female' woods in boatbuilding. These could be summarised as, boats built of female woods sailed faster at night than boats of identical type built of male woods!

The existence of ships, boats and even parts of boats in some early Anglo-Saxon burials in England underlines the ritualised symbolic importance of boats and ships in pagan times. The power of boats and ships as symbols is of course particularly well known in Scandinavia from prehistory onward (Crumlin-Pedersen and Thye eds, 1995). However, this field of enquiry lies outside the limits of this study except where it may have some practical implications for the recording and analysis of nautical or possibly nautical woodwork. Even in Christian medieval England ships were used as powerful symbols on town seals, pilgrim badges, and most relevant to this study, church doors (Chapt.4 particularly 4/4). Interestingly in later medieval England shipwrights might be asked to fasten an external door together with typical iron rove nails but were not asked to carry out woodwork inside large buildings or churches (Goodburn 1991:105). Those spaces were apparently the domain of the 'carpenter' and at least theoretically guild demarcation lines were observed in the later medieval period contrasting with no apparent prescription of the use of boatbuilding techniques inside buildings for the early medieval or 'treewrighting' period (expanded below).

3/2/8 THE CRITICAL INTERROGATION OF HISTORICAL AND ICONOGRAPHIC SOURCES

Though this work is primarily archaeological in its source material some historical and iconographic evidence is also drawn upon. The both sources can now be offered up against the archaeological material and information gleaned from experimental and ethnographic work and interrogated in detail (Chapt. 8). This process holds out the prospect of deepening our knowledge of boat and ship building and essential ancillary trades during our period. This process is possible now due to the accumulation of large amounts of archaeological evidence unknown to the early 20th century researchers into the shipbuilding documentary sources (eg. Johnson 1927). Conversely it is strange that little in-depth use has been made of the archaeological evidence by most recent maritime historians in Britain and vice a versa. However, archaeologists can still make critical use of archaeologically averse historians otherwise thorough and valuable work on the documents (eg. Friel 1986, 1995). This contrasts with the use of medieval written evidence by Christensen in connection with the Bryggen nautical finds. Here he attempts to unite the two disparate sources in a practical way despite lamenting the lack of detail in the local sources for such areas of interest as the details of shipbuilding (Christensen 1985:248). Chapter 8 provides a reconnaissance of the potential of this field with an examination of several key English sources and what is probably their particular richness. It is clear that much further work could be done in future through collaboration with a suitable medieval documents specialist who can read the original texts.

The iconography of medieval boats and ships on coins, in paintings and graffiti has been a focus of intensive study and debate for many researchers in medieval nautical archaeology. The general drive of most of this work seems to have been to attempt to identify particular ship types with particular ship names and general hull or sailing rig forms or to show particular modes of use (eg. Crumlin-Pedersen 1983:2, 1997:172, Christensen 1985:238, Ellmers 1985). However, sometimes the concern has been to find parallels for particular technical features of more direct bearing for this study (eg. Fenwick ed. 1978:235, on the form of clinker hood end boards). In this study though, the key iconographic focus is on images of ship and boat building and related activities rather than of finished vessels (8/3).

3/2/9 SUMMARY

The synthesis of approaches outlined here suggests that nautical timbers, articulated hull sections as well as more complete finds are loaded with subtle technical, environmental and socio-economic information, specifically concerning;

1/ boat and ship building technology and the organisation of boat and ship yard labour, tools and techniques, which together constitute boat and ship building 'practice'.

2/ contemporary woodlands and other types of tree bearing land (treeland) and their management (woodmanship).

3/ the work of ancillary workers such as woodsmen, sawyers, clovyers, boatmen and sailors, iron smelters, tar makers, and carters etc.

The results from these different areas of investigation will be drawn together to contribute to a deeper understanding of many of the crafts involved in ship and boat building and something of their economic and social situation in medieval and Tudor England c.900-1600AD. The generalisations and specific conclusions produced should be more than just isolated and technical but cast light on boat and ship building as technical and economic activities set in particular social, environmental and technological circumstances. Some comparison with studies of 'land woodwork' over the same period is essential to demonstrate what may be particular to the nautical evidence and this is noted where relevant below. Paradoxically detailed study of structures designed to operate in a water environment can help build a fuller picture of changing cultural landscapes, and aspects of the lives of those who lived and worked there from shipwrights by the tidal water to rural woodsmen who had probably never seen it.

4/ DEPOSITIONAL PROCESSES FOR MEDIEVAL SHIP AND BOAT REMAINS

In chapter 3 a frame work for understanding the processes behind the building of vessels in pre-Norman Conquest and medieval England was described. Different processes behind the building of the archaeological record of ship and boat finds which are central to this study are now considered below. Please note that factors such as ship burial and the use of ships for defensive barriers are not considered here as neither has direct relevance to the material central to this study (but see Crumlin-Pedersen 1985b for a review of these issues).

4/1 CONDITIONS NECESSARY FOR THE SURVIVAL OF MEDIEVAL NAUTICAL TIMBERS

For timbers to survive from the period c.900 to c. 1600 AD in Britain they must either have been, deposited in totally waterlogged conditions free from marine borers or, incorporated into surviving standing buildings.

4/2 THE SURVIVAL OF NAUTICAL TIMBERS IN ENGLISH MEDIEVAL STANDING BUILDINGS

There is a common assumption that the reuse of 'old ships timbers' in buildings was a regular occurrence in medieval England. However, no well substantiated archaeological example of such a practice in a standing medieval structure is known to this writer. Leading figures in early timber building research in Britain have also come to this view. Richard Harris, for example, suggests that references to 'ships timber' may actually refer to a particular quality or type of timber, rather as we refer to the highest quality of waterproof plywood as 'marine ply' today

(Harris 1978:19). In practice naturally curved timbers are sometimes confused with ships timbers, a misunderstanding brought about by the universal use of straight timber for building during the last 150 years in England.

There may be, however, some tantalising suggestions of the late medieval reuse of ships timbers in Stows 'Survay of London' published in 1603. He describes a catering establishment on the waterfront in the Billingsgate area, run by one 'Mother Mampudding' (Wheatly ed. 1987:124-5). The building had a hall which was built in an unusual style, with main posts set in the ground and boards forming the roof held together with 'rough and clench..', ie. rove nails. Also Salzman traced an earlier reference of 1223 to what may have been a similar phenomenon of using old ship planking for a turret at Dover (1952:200).

4/3 THE SURVIVAL OF NAUTICAL TIMBERS IN PRE-CONQUEST EXCAVATED BUILDINGS

There is also some evidence that boat timbers may have been reused in now decayed pre-Conquest buildings. Excavations at Pudding Lane, London revealed rove nails lying along the line of a decayed timber wall of a building (Horsman, G. Milne and C. Milne 1988:81). At Yeavering, in Northumbria rove nails were also found lying along a decayed timber wall of a large early Anglo-Saxon building (Hope-Taylor 1977:86). An obvious explanation for this patterning in the deposition of distinctive nails, is that sections of hull planking, might be reused in the manner of panels of 'clapboard', but this is not the only possible explanation.

Clear evidence of the reuse of nautical timbers in the underground remains of pre-Conquest buildings has recently been recovered during the Museum of London Bull Wharf excavations (Goodburn 1995). Here sections of four oak frame timbers from a clinker built vessel were reused as heavy stakes in what appears to have been a wall (fig.33). Additionally, on the same site an oar or paddle blade and a small boat frame timber were used as bearers for two pre-Conquest floor joists (fig.33f). In the excavations of medieval Bryggen, Bergen, Norway, many relatively straight nautical timbers such as masts, and ship cross beams were also found reused in building foundations (Christensen 1985, and fig.33c).

4/4 SHIPWRIGHTS, DOORS, ROOF CLADDING AND THE SYMBOLIC SHIP

Doors

The situation is much complicated by the familiar use of boat type rivets and indeed treenails in medieval and possibly even Anglo-Saxon church doors (Hewett 1985, figs 149 and 181, here fig. 33a). The use of boat style fastenings, types of overlapping oak planking and commonly, iron ship motifs in such high status doors suggests the involvement of shipwrights in their building. Some degree of confirmation of this hypothesis is provided by an early 14th century London record. In 1311 shipwright John Mitchell and one William Litelwille fastened together a door at the Tower of London with boat rivets (this being a two person job in a structure such as a large door or large boat (Salzman 1952:309).

The symbolic and structural links between ships and aisled buildings especially churches is signposted by the use of the terms 'nave' and in the Scandinavian languages rather more explicitly 'skip', for the central area of an aisled building.

Roofs.

For some time architectural historians have described similarities between the structures of medieval Norwegian stave church roofs and features of contemporary or earlier ship construction. The widespread use of knees was common to both types of structure, though their use in other types of medieval timber building was rather limited (see Bugge,1983).

The recent work of J. Godal further develops the connections between church roofs, ships and boats in several ways (Godal 1994). He reports that church roofs in Norway were secure dry places where sailing gear such as ropes and sails were often stored in medieval times. He also describes some original roof cladding surviving under more recent roofs, which were built of cleft and hewn overlapping planking laid in a style reminiscent of a clinker hull. The scarves in the ends of joining planks, and the overlaps were weather proofed (but not fastened together) by luting with organic cordage and heavy textile strips. These materials are interpreted as parts of sails and rigging.

The dragon's head terminals on the roofs of some medieval Norwegian stave churches and on certain classes of large Viking longships provide another well known, symbolic parallel.

Anglo-Saxon boat nails in Anglo-Saxon buildings as original features?

The recent find of reused architectural timbers, tree-ring dated to c. 980 AD near Queenhithe in the City of London further complicates the picture (Tyers 1991, Goodburn 1997c). Here what appear to have been arcade posts, from a Late-Saxon building had planking fastened to them with rove nails driven through wooden plugs in exactly the same style as was used in the contemporary Graveney style clinker boat planking (fig. 33b).

Additionally several recent excavations in London have produced radially cleft oak clapboard from buildings. (fig.82). These clapboards were found to have been fastened to other timbers with boat type bulbous-headed, oak wedged, treenails of non-oak wood (probably willow or poplar, *Salix or Poplus* sp.). Though these boards have some of the characteristics of contemporary clinker boat planking they can be distinguished from it by the following; they are minimally trimmed having fragile feather edges, treenails are not found along the edges or in arrangements that would be commensurate with use as boat planking, and no traces of tarred luting have been found.

4/5 SURVIVAL IN POST-MEDIEVAL ENGLISH BUILDINGS

In the post-medieval period the recycling of ship timbers for structural purposes in buildings was common in some areas (Goodburn 1991a:113). This is particularly true in the vicinity of the naval dockyards such as Portsmouth, and Chatham where large timber buildings survive with many timbers taken from naval vessels. For example, the 'Mast Shed' and 'Mould Loft' at Chatham dockyard, incorporate many large naval ship timbers. In the wheelwrights shop in Chatham dockyard a large number of reused ships knees are clearly visible, some having moulded corners and others being more plainly finished (fig.33d).

4/6 WRECK SITES, SCUTTLED SHIPS, AND HULKS NOW IN THE TIDAL ZONE

No attempt will be made here to cover underwater finds in English waters dating from c. 900 ad to c. 1600 in detail. Firstly, there are very few recent finds and secondly some sites are the subject of current or intermittent research as yet little published (eg. J Adams, Pers Com. re- the Guernsey medieval wrecks). However, note must be taken of key finds which have provided a framework for comparison of fragmentary 'terrestrial' finds which form the main source material of this work (Append.6).

The 11th century Skuldelev vessels, deliberately sunk to form a defensive barrage are clearly the most important published under water finds of the pre-Conquest period in NW Europe (Olsen and Crumlin-Pedersen 1978). Later finds from Danish waters include important wrecks such as the 13th century Kollerup cog, and the mid 14th century Vjeby vessel which is known to have travelled to England as English coins and ballast stone were found in her (Crumlin-Pedersen 1983). A key point raised by Crumlin-Pedersen in this context is that the very process of travelling may change a ship and she may end up far from her home port (Crumlin-Pedersen 1985b:218).

The next period from which we have wrecked vessels found under water in maritime locations, in or relatively near British waters is, the later 15th and early 16th centuries. These vessels include the clinker built L'Aber Wrac'h vessel, the Studland bay find, and the Cattewater vessel both the last being carvel built (L'Hour and Veyrat 1989, Hutchinson 1991, Redknap 1984). For notes on the Mary Rose of features relevant to this study see Appendix 6 and relevant sections of text below.

From low energy riverine or haven locations, particularly in continental Europe or Scandinavia, we have a wider coverage of vessel types and dates. The varied fleet found in Kalmar's old harbour in S.E. Sweden (Akerlund, 1951 and chapter 2 this study) being the most impressive collection of finds. Large, medium sized and small vessels were found there and at the Viking period settlement of Hedeby, where they were investigated in detail (Crumlin-Pedersen 1997). Both these last two projects have provided much comparative material for this study.
Greater London has also provided a range of pre-Norman Conquest and medieval wreck finds, small dugout vessels from the river Lea in east London and medium sized craft from the Thames at Blackfriars, in the City, (Marsden ed. 1989, Fenwick 1978 and Marsden 1996). From the Wesser river in N.W Germany, we have several medieval wrecks, from the famous sea-going cog from Bremen (Kiedel and Schnall 1985) to a much smaller flat bottomed river craft 'Karl' as yet un-published (Per.Hoffman, Pers Com. 1990. Append.6).

Of all the nearer European countries the Netherlands has yielded up the most varied collection of later medieval wrecks recovered from the low energy deposits of the recently reclaimed polders (Reinders 1985). The ancient silted river channels of the Utrecht area have also produced several finds (Vlek 1987).

4/7 EFFECTS OF WRECKING ON THE TYPE OF SURVIVAL OF VESSEL REMAINS

The study of the taphonomy of riverine and marine wrecks is a huge field currently being researched by diving archaeologists with more relevant experience than this writer (Muckleroy 1978). However, some generalisations are still useful in the context of this study. Wreck finds tend to be characterised by the loss of the upper hull parts, not quickly buried by sediments, through the action of marine organisms and wave or tidal action. In maritime wrecks the metal fastenings are often completely destroyed by corrosion, as in the Skuldelev finds, though concretions may survive that can be radiographed.

Unless a vessel came to rest upside down, as was the case with one of the Walthamstow post-medieval barges from the River Lea (Fenwick 1978), or on its side, as in the case of the Mary Rose, the upperworks of the hulls are rarely preserved. Most the timbers of wreck finds in high energy exposed environments are virtually destroyed, though the best preserved examples may consist of the central portion of the lower hull where it has been protected by cargo or ballast. In sheltered environments, with few marine borers the preservation of wreck finds can be remarkable. These conditions occur in very deep locations and cold fresh water like the Northern Baltic, where well preserved late and post-medieval wrecks are being investigated. However, even in the best conditions paint and other surface treatments rarely survive on wreck finds (Append.12).

In shallower, rapidly silting environments preservation can also be extremely good, though vessels are often distorted by the accumulation of overburden silts such as in the case of the medieval Kentmere extended dugout boat discussed below (Chapt. 6). It is in these low energy environments that we tend to get the best preservation of toolmarks.

4/8 THE PROCESS OF "HULKING" BOATS AND SHIPS.

Here the term 'hulk' is taken in its modern sense of an old vessel, past its active use, hauled onto a tidal foreshore, river bank or up a backwater. In recent times large redundant vessels would sometimes be employed as warehouses or even prisons. Relatively small vessels down to about 10m length, were sometimes converted into static buildings, for gear storage or occasionally dwellings, and such can still be seen around the British and French coasts and estuaries, for example. Eventually, these vessels become too decrepit for further use and they are totally abandoned, and the upper parts may then be cut out for fuel or recycling, see below.

A pre- Norman Conquest example of the hulking of a vessel is the Graveney boat found partly dismantled up a small tidal creek off the river Swale, near the mouth of the Thames (Fenwick ed 1978). It is also probable that some of the dugout boat finds made in the London area were abandoned worn out vessels, though the records of their excavation contexts are all too poor to establish this with certainty. It is clear that much of the fragmentary nautical material analysed in chapter 7 was derived from hulked vessels, as well as systematically broken vessels. During a site visit it became clear that the Magor Pill vessel had also been hulked and had had some of her planking at the bow had been removed in the distant past. This last example powerfully makes the point noted by Crumlin-Pedersen that boat and ship finds may help to define ancient coast lines and extinct channels (Crumlin-Pedersen 1985b:216).

4/9 THE EFFECTS OF HULKING ON THE SURVIVAL OF BOAT AND SHIP TIMBERS

Finds of abandoned vessels are likely to be damaged in a predictable way with much of the drier more accessible upper hull being cut away for firewood and structural reuse in near by river walls or similar structures (see Fenwick ed 1978:fig.8.16, which clearly shows secondary axe marks from breaking the Graveney boat). The now well documented practice of reuse of boat or ship timbers in building new vessels may also have provided a motivation for the dismantling of abandoned hulks in the past (see Goodburn 1988:425, here fig.34b, and Olsen and Crumlin-Pedersen 1978:106). Shipboards in particular were valuable and much reused.

Where were hulks broken up?

The finds of distorted pre-Conquest iron boat fastenings in foreshore deposits at Thames Exchange, and Vintners Place in the City of London, may be evidence of the breaking up of abandoned vessels (fig. 34b). However, it is possible that their presence could indicate that planking repairs were being made to clinker built vessels on the strand. Alternatively hulks, might have been sold to be broken up for local reuse where there would have been a ready market for the timber and fuel wood.

An important effect of abandonment and all types of structural reuse

The act of cutting up a vessel usually camouflages the scarfing pattern used by the original builders to assemble both frame and plank elements, therefore the traditional rules governing the arrangement of these patterns are difficult to reconstruct from fragmentary remains. As the lengths of the timbers used by the ship and boat builders are also often reduced it can frequently be difficult to reconstruct the length of the 'parent log' originally used for the production of those timbers. This is the important first stage in the reconstruction of the hypothetical treeland revealed by study of such remains. (Append.2).

4/10 NAUTICAL TIMBERS RECOVERED THROUGH RESCUE ARCHAEOLOGICAL WORK ON LAND

The boom in rescue archaeology in Britain since the 1970's led to the discovery of enormous numbers of waterlogged timber structures of c.900-1600AD. This was particularly true of work carried out in the historic cores of urban port areas. Parts of Greater London have been particularly productive of waterlogged nautical timbers (Goodburn 1988,1991, Marsden 1979,1994,1996). This phenomenon was already well known by archaeologists working in the historic port areas of Bergen, Norway, from the mid 1950's and resulted in the publication of a huge corpus of material (Christensen 1985).

Rescue archaeology projects in the following British towns and villages have revealed pre-Conquest, medieval or early post-medieval reused nautical timbers or abandoned vessels since 1970 (see Append. 6 for list of site names and selected references). Much of the material is not published in any detail but it is possible to list the town (or village) names in approximate order of the quantity of material excavated. A listed publication indicates weather any of the finds from the named area have been published in anything more than cursory detail. At most of the following locations fragments of more than one vessel were recovered.

City of London (see Append 6.)
Greater London "
Perth, Scotland (M. Dean Pers Com.)
Poole (Watkins 1994)
Lincoln (A. Vince Pers Com.)
Bristol (B. Jones Pers Com. And some information in Hutchinson 1994a:110)
Grimsby (D. Evans Pers Com.)
Hull "
Doncaster (Assistance with recording provided by this writer, and J. Spriggs Pers Com.)
Newcastle (O'Brien et al 1988)
Hartlepool (Young 1987)
York (Goodburn 2000b)
Medmerry, W.Sussex (Goodburn 1987)
Reading (? News item footage on national television 1988, this author attempted to obtain information in writing from Wessex Archaeology three times with out reply).
Camber, Kent (Goodburn 1990)
Norwich (R. Darrah Pers Com.)
Southwold, Suffolk (Buss creek V. Fenwick Pers Com.)
Yarmouth, Norfolk (R. Darrah Pers Com.)
Southend, Essex (Hutchinson 1994a:123)
Newport, Gwent, Wales, (Hutchinson 1984)

(A useful list of broadly medieval finds including antiquarian examples can be found in Hutchinson's review work (1994:191), See fig.36 for the location of the sites.)

In addition a number of other historic port towns in N.W Europe have produced large collections of similarly reused nautical timbers some are listed below.

Publication references are noted next to those that have been published in any detail as far as the author is aware.

(see fig.36 for the location of the sites)

Bergen (Christensen 1985)
Dublin (McGrail 1993)
Hedeby (Crumlin-Pedersen 1997)
Schleswig "
Trondheim (R. Bartokowiak Pers Com.)
Wolin (Filipowiak 1981
Novgorod (Crumlin-Pedersen Pers Com.)
Tonsberg (Christensen Pers Com.)
Amsterdam (Amsterdam Town Museum display ?)
Gdansk (Smolarek 1981)
Tiel (Tiel Archaeology display at the Medieval Europe 1997 Conference Brugge, Belgium)

Clearly the potential corpus of material relevant to this study is huge and the detailed publications have been trawled for comparative evidence. Those consulted in particular detail are the publications of the Bergen finds (Christensen 1985) and more recently the Hedeby, Schleswig and Dublin finds (Crumlin-Pedersen 1997, McGrail 1993). A small amount of the material covered in some of these corpuses has also been seen during the course of this study as noted in Appendix 6.

4/11 LONDON FIND SPOTS; A REGULAR PATTERN?

It is instructive to consider the huge amount of material from the City and Greater London area against the background of the local geological survey map. This map shows the main zones of alluvial deposition, which mark extinct watercourses. Clearly, these are the areas where archaeologists should expect to come across; waterlogged structures or isolated timbers of nautical origin, wreck finds such as those of the river Lea or Thames at Blackfriars (Fenwick 1978, Marsden 1979) or abandoned vessels like the Graveney find or Woolwich ship (Fenwick ed. 1978, Salisbury 1961).

Figure 37 shows how the find locations lie within or very close to these alluvial zones, often focused on the edges of known historic settlements. Small pockets of alluvium are ignored or have not been recorded.

4/12 CONTEXTS FOR THE STRUCTURAL REUSE AND ABANDONMENT OF NAUTICAL TIMBERS IN THE WATERFRONT ZONE

Reuse as revetment sheathing

Medieval clinker boat or ship boards are frequently found reused as sheathing for revetment structures lining water courses, such as river walls, or ditches and in linings of pits and tanks. Most of this material was reused in small articulated sections or as individual boards as at Thames Exchange, Vintners Place, and Bull Wharf Late-Saxon revetments from the City of London (fig. 38a Append.6). However, clinker planking was also sometimes reused in very large articulated slabs which can give us some idea of the shape of the parent vessel. In the case of the Kingston Nos 1 and 2 boats for example. Over 14m of the side of an old clinker built vessel, of c. 1300 AD date was reused in one piece in the case of the No 2 boat (Append. 6). At the time of writing (edited 2002) this is the largest section of a ship of this period to have survived intact in England with the possible exception of the partially investigated Sandwich ship. Some disarticulated salvaged remains of the Sandwich ship are currently undergoing dating and analysis work (G. Milne Pers Com. And Append.6). This statement graphically illustrates the fragmentary nature of our current national record (Goodburn 1988 and 1991 and Chapt.7). Very recent work on wrecks near St Peters Port Guernsey the Channel Islands, technically English waters, is also likely to provide evidence of substantial hull remains of this period in the near future (J. Adams Pers Com.). Boards and planks that were relatively easy to reuse were valuable even second hand and are by far the most common types of medieval nautical woodwork to be found in England (Chapt. 8 Table 6.).

For brevity a series of sketch Figures have been prepared to illustrate and graphically summarise the range of modes of reuse found archaeologically in London over the last few years (figs. 34d,e and 38).

4/13 BIASES IN THE MATERIAL RECORD OF PRE-CONQUEST AND LATER MEDIEVAL NAUTICAL TIMBERS FOUND IN REUSED CONTEXTS

In section 4/9 above some of the limitations of the study of reused nautical timbers were described. Selection and modification for reuse tends to impose other biases on the material corpus that survives, which are listed below.

a/ The shape of the parent vessel is rarely preserved, though some degree of localised reconstruction may be attempted using the shape of strake fragments and frame fastening locations.

b/ As most of the timbers reused were taken from old worn vessels little of the original finish remains, if any. Only rarely can we reconstruct the nature of the surface finish or 'paints' applied to timbers from c.900-1600AD. However, in London and elsewhere many samples of such materials have been taken by this author but unfortunately very few have been analysed scientifically.

c/ Patterns of wear and erosion tend to form on the surface of many of the timbers during the reuse phase which can obscure evidence of the life history of the parent vessel. Additionally extra fastenings may also be driven which bear no relationship to the original use of the timber.

d/ The less three dimensional a boat or ship element was the easier it was to reuse, a practical requirement which resulted in the flattening of curved hull sections and the preferential selection of the straighter individual timbers and sections of planking. Thus, we have vastly more planking than frame timber elements surviving from our period, and far more planking sections from the middle of hulls than the ends.

4/14 PAGAN SHIP OR PARTIAL SHIP BURIAL.

The practice of burying high status individuals in ships or symbolic ships in N.W. Europe is too well known to require detailed consideration here especially as in the English context they predate the study period very considerably. However, although the finds of Early or 'Pagan' Anglo-Saxon burial boats or ships are only decayed impressions with out surviving timber we must refer to studies of them for the following reasons (Bruce-Mitford and Care-Evans 1975 and see discussion in chapter 2.). They have provided background information on the earliest English planked ship and boat building for which we have no solid timber evidence to date. For example, traces of the distinctive use of wooden rawl plugs with small iron rove nails (Append.9) have been seen in Pagan Anglo-Saxon burial contexts in the Caister By Norwich cemetery (J.Bill Pers Com.). This shows that what appears, in the 10th century, to be a distinctive feature of one style of English early medieval clinker boatbuilding was in fact in use much earlier. The carefully excavated impressions of two small expanded dugout boats used for burials at Snape in Suffolk have also informed considerations of the possibility of expanding oak dugouts which we appear to have surviving elements of in later periods (7/3).

In exceptional circumstances, which seem to have only occurred occasionally in Norway (eg. at Oseberg, Gokstad: Christensen 1986) and in a somewhat earlier period in Southern Denmark in the Nydam bog site (Rieck and Crumlin-Pedersen 1988:103), the timbers of deliberately buried vessels may survive. These vessels loom large in the archaeological record just prior to the period covered in this study. The evidence from selected finds of these earlier periods has been briefly covered in the literature survey (Chapt.2) as the material represents the work of ancestors to those who built the vessels which are central to this study.

5/ THE CLAPTON DUGOUT BOAT: BUILDING A SMALL 10TH CENTURY SAXON RIVER BOAT

5/1/1 GENERAL DESCRIPTION

The Clapton dugout boat, or 'Clapton logboat', has been described in detail elsewhere, (Marsden ed. 1989). Only an updated outline is presented here. The vessel was found during building works in October 1987, close to the west bank of the present river Lea, E London (fig.39). It had been damaged by machinery during excavation but enough of the boat survived for its original shape and dimensions to be reconstructed with reasonable certainty (fig.40). It was c. 3.75m long, with a beam of c. 0.67m and depth of 0.4lm amidships. It should be noted, however, that the series of measurements of an accurate replica, taken over a nine year period, suggests that these dimensions would not have been those of the newly built original vessel (see below).

The damage to its wider end renders conjectural the reconstruction of the precise form at that point, but the existence of a "chine", similar to that at the narrow end, suggests that the broader end was similar. The narrow end has been thought to be the bow but trials of the replica, Ravensbourne, suggest that this assumption requires further testing. Some experimental paddlers found the boat easier to propel with the broader, presumed stern end, forad. In some recent dugouts the broader end forms the bow (eg. Leshikar 1975:48). The form of the vessel can be summarised as square ended, similar to a recent upper Thames plank-built punt (see Rivington 1989) but with a rockered bottom, and rounded bilges (fig. 40).

The vessel has a distinctive bulkhead left in solid near midships, as do some other finds from the Lea and Thames. It would appear to be one of four examples of a distinctive, localised tradition of small boatbuilding (Fox 1926:143, and McGrail 1989:103). The bulkhead was thought to have been left for localised strengthening, or possibly, as a seat (McGrail 1989:103). In the replica it has been found to work as a seat only when the vessel has three crew aboard or a similarly balanced load: a single person can not propel the boat easily from that position.

The 'bow'end was pierced with a 40mm dia. hole. This is thought to have been used as a mooring pole socket and/or for securing a line (Marsden 1989:95), a dual purpose which it serves well in the replica. The mooring pole inserted through the hole into the soft river shore allows the boat to ride up and down with changes in water level whilst holding it in exactly the same spot. Mooring using poles called 'ryepecks' instead of ropes is traditional for Thames punters even today, although the poles are now placed along the side of the rectangular craft rather than through part of it.

5/1/2 DATING EVIDENCE

It was immediately clear that the presence of crisp, flat toolmarks, clearly made with metal tools, ruled out the popularly ascribed "Stone Age" date. The bored, rather than gouged, holes suggested a Late Iron Age or later date. The relatively small size of the vessel best fitted a pre-Conquest or medieval date range, when larger craft seem to have been plank built. In due course tree-ring analysis showed that the parent tree was felled between c. 950-1000 AD. The lack of measurable sapwood prevented closer dating (Tyers 1989:104).

5/1/3 POSSIBLE ROLES FOR THE VESSEL

This vessel was likely to have been a small, multi-purpose craft probably used for ferrying, carriage of small loads, fishing, fowling and personal transport. Trials of the replica Ravensbourne, indicate that the boat could have carried a total load of about 200kg (4881bs), or a crew of one adult and cargo of about 110kg with freeboard amidships of 9.5cm (fig. 41, Goodburn Forthcoming a,). This low freeboard is adequate for very sheltered waters, and is roughly what can be seen in photographs of some loaded dugout boats still in use in sheltered waters today (eg. Roberts and Shackleton 1983:31). These freeboard and load statistics were accurately predicted by McGrail in his desk-top study of the potential performance of the Clapton dugout boat (McGrail 1990:131). Trials carried out in shallow sheltered water, broadly similar to the conditions in the River Lea before canalisation, show that the boat, could have carried a maximum of up to three adults of medium weight with a freeboard of 9.5cm.

Experiments with propulsion in a shallow water operating environment indicate that punting was probably the normal method of propulsion (fig.42). In Ravensbourne progress with paddles of Late Saxon type is slow and directional stability very hard to maintain even for experienced professional paddlers of small canoes and kayaks. With a pole, however, a moderately experienced punter can travel at over 3 knots, steer far more easily and see better to avoid obstructions. An experienced Thames punt racing champion, Mr. B. Maidment, propelled the partially loaded vessel at over 4 knots, which is far faster than is practicable using paddles. At about 3 knots using paddles the replica becomes extremely hard to steer. McGrail calculated that the replica would realistically have had a paddle powered top speed of about '..2.5 kts when paddled by a 3-man crew', but that the vessel had a theoretical maximum speed of 4.8 knots (McGrail 1990:132). Unfortunately the use of a pole was not considered in the theoretical analysis which resulted in a considerable under-estimate of the potential performance of the original vessel.

The unusually great thickness of the boats bottom (100mm) acts, to some extent, as ballast, an aid to stability. Boarding from a river bank using a steadying pole was easy, particularly with the boat end on.

5/1/4 BUILDING A FULL-SIZED EXPERIMENTAL REPLICA

As part of a continuing analysis of the technological, environmental, and logistical requirements for building small oak dugouts an accurate experimental replica of this vessel was built. The toolkit used was derived from the toolmark analysis of the find and what is known of late Anglo-Saxon tool kits in general (Goodburn 1989, 1992, and below). The parent tree chosen was very similar to that used in the original boat (see below, and Goodburn and Redknap 1988, and Append. 4a.). The subtle new insights gleaned through this and subsequent similar dugout boat building projects have been drawn upon for this chapter. The project had the side benefits of; producing a vessel for life-sized trials and educational display (see above and Goodburn Forthcoming a,). Attempts have been made to define the nature of experimental boat archaeology in Britain (eg. McGrail 1986). He predicted very limited results in terms of new information gained. However, in the writers experience far-ranging, often surprising new insights and lines of inquiry can be generated by such work (Crumlin-Pedersen and Vinner eds. 1986, Crumlin-Pedersen 1995, and Chapts 6,7,8, and 9 here). It is regrettable that the approach has been so little used in Britain. Not only is the potential research value underestimated but so is the value of such projects for public presentation of a complex field and the opportunities such projects provide for training of nautical archaeologists and ethnographers (Goodburn 1993,c,).

5/2 RECONSTRUCTING THE RAW MATERIALS USED IN THE ORIGINAL BOAT

Here all the materials used in the boat from the main hull log to the ash treenails and stopping materials are considered to gain a fuller picture of how the building and repair of the boat sits within a particular environmental and social niche. .

5/2/1 TIMBER

It is very difficult to speculate on how the parent tree for the Clapton boat was selected. The ethnography of pre-industrial boatbuilding indicates that the selection of a suitable tree for dugout building often involved ritual activities (eg. Best 1976:75, McGrail 1978:30). But we have no sources of evidence bearing on this theme at this period in England.

Parent log size

It has been claimed that this boat had been hewn out of the bole an oak about lm in diameter (Marsden ed. 1989:92). However, experience building the replica and five other dugout boats (Append. 4), suggests that it would have been built from a much smaller log, about 0.80m in diameter at the mid point (Also see a similar parent tree reconstruction by Billamboz and Schlichterle 1987). It would have been 3m from the ground to the first major branching point (fig. 40 and Marsden ed. 1989:92 cf. Goodburn 1992,b, and Append. 2). Examination of the conserved original boat (July 1992, in Hackney Museum) revealed that the pith of the tree was rather more crooked than originally recorded.

The parent log would have been about 3.8m long with a mid length diameter of about 0.80m, and have had a slight bend in it, which survived in the finished hull as a slight asymmetry of plan. It is assumed here that the largest bottom log from the parent tree was used, but it is possible, although perhaps less likely, that an upper log of a tall oak could have been used. In the first case the parent tree could have grown in either a rather open coppice with standards type woodland (the type of parent tree used for the replica) or, less likely, in wood pasture. The tree selected was thought to have been between about 200 and 250 years old; 160 rings, without the sapwood-heartwood boundary were counted (Tyers 1989:104). Practical experience suggests that it is unlikely very much heartwood was cut away and that the true age of the parent log might lie between about 170 and 200 years.

Some defects in the original log

The original vessel and replica were built from logs with rather spiral grain that is common in oaks from moderately open locations and in some standards grown in ancient coppice with standards type woodland today. This feature together with the position and size of the knots has some important implications for the potential value of the parent log and labour input required during the building (see below 5/10, and Chapt. 9.). The use of oaks with defects such as spiral growth has also been noticed in some broadly contemporary dugout boat finds from the Hedeby region (Crumlin-Pedersen 1997:184). The small, shallow and heavy nature of the vessel suggests that she was probably constructed locally. This hypothesis is supported by the close match of the tree-ring sequence to the London chronologies which suggests that the parent tree grew in the London hinterland (Tyers 1989,104). We might also suggest that the parent tree probably grew close to the edge of one of the channels of the R. Lea, as this would have made moving the roughed out boat far easier. The fact that the boat had the distinctive form particular to the vessels of the Lea also suggests a local origin (McGrail 1989).

5/2/2 WOODEN FASTENINGS AND BUNGS

A missing timber, indicated by an unworn band on the bow had been fastened with ash (*Fraxinus excelsior*) treenails c. 20mm diameter. These were carved from billets rather than whole stems. The two wooden bungs in the bottom of the boat appear to have been made from oak billets and were c. 23mm in diameter. They were clearly bungs for thickness gauge holes rather than true fastenings.

5/2/3 WATERPROOFING MATERIALS

No stopping or caulking materials were found surviving in the large split running from the 'bow' towards amidships after cleaning at the museum. This may imply that any such material was heavily degraded and inadvertently washed away. However, some form of stopping to slow or prevent leakage would have been absolutely essential. Many materials are known from ethnographic sources such as animal fat, clay, and beeswax (eg. Reynolds 1968:120). These materials would have been hard to recognise during cleaning. On the Thames, sticky river clay was even used as a temporary leak stopper in old plank built working craft into the 20th century when it was known as 'Blackwall caulking'.

One of the bungs in the bottom of the boat was stopped by a blob of black tarry material, which was identified as pine tar with about 10% beeswax added (Evans 1989:96). No trace of any overall 'paint' covering was found surviving on the boat. However, some surface treatment would have been essential (see 5/8 below). The analysis of two small samples taken sometime after excavation around two possible areas of pitch deposit showed no trace of amino acids that would have indicated the use of an animal derived material (Evans 1989:97). However, this work can not be considered conclusive due to the lack of systematic sampling, small sample size and the disturbance of the surfaces during excavation and washing.

5/3 EVIDENCE FOR EXTRACTION OF THE RAW MATERIALS

Having searched for and found a suitable log and other materials, and having had the permission to use them the builders of the boat had to gather them or 'extract' them. Moving the partly worked hulls of dugout boats is an important logistical issue often involving a large group.

5/3/1 THE MAIN LOG

The weight of the green parent log for the Clapton boat can be calculated to have been about 2 tonnes (Append.3). Practical experiment and most records of pre-industrial dugout building known to this writer suggest that the log would have been partly worked to, reduce its weight and expose defects before transport to the finishing site (eg.McGrail 1978:30, Leshikar 1975:5, Tallec 1991:45, Reynolds 1968:117). The coarsely roughed-out, totally green, dugout, in a condition where it could carry a paddler would have weighed less than a quarter of that of the parent log.

Log rolling?

Occasionally, archaeological accounts of this aspect of dugout boat building suggest that bucked and lopped logs were, or could have been be rolled, to a waterside site (eg. Millet and McGrail 1987:124 but cf. Millet and McGrail 1987:128 where the opposing view is given). This seems a highly unlikely general practice for early N. Europeans, due to the weight of the parent oak logs and the need to build a track, wider than the boat was long, through woodland. Dragging the roughed-out hull over a simple 'skid row' of branches only about 1m wide in this case would have been the most likely option. With the replica this was possible with three people, the number the roughed out vessel could just carry when launched.

5/3/2 OTHER MATERIALS

The ash billets required for the bow strap fastenings could have been produced from a short log or cleft offcut. The oak billets for the bungs could have been made similarly. The strap used to repair the bow could have been made from a small cleft timber offcut. The beeswax used in one of the bung holes could have been gathered relatively locally from wild or domestic bees, perhaps by the boatbuilders themselves.

5/4 TRADED MATERIALS

The pine tar would have to have been imported from an area where pines were common at this time such as, northern Scotland, Alpine central Europe or most likely the Baltic region. Historical ecologists of British woodland are clear that there is no evidence for trees of the genus *Pinus* in pre-Conquest England (eg. Rackham 1976).

5/5 EVIDENCE FOR CONVERSION METHODS- PRIMARY WORKING AND WORKING THE TIMBER GREEN

The crisp smoothness and fairly wide spacing of the best preserved toolmarks suggest that the timber was green when worked. There is little of the tearing often visible when seasoned oak is hewn. Practical experience also shows that toolmarks are set closer together in harder seasoned timber than green, as the tools used penetrate less deeply with each blow.

Practical experience and ethnographic parallels also suggest that the seasoning of logs for dugout building was never likely. Firstly, large oak logs kept in the round develop 'shakes' which would render the log unsuitable for producing a watertight hull. Secondly, before the advent of chain saws and other power tools, all European large scale woodworkers preferred to work timber green. This is because timbers in an unseasoned condition are much softer and perhaps two or three times as easy to work, although they are also heavier. We can suggest that the strategy would have been to carry out most of the heavy work with the timber in green condition and then, if required, allow it to season or partially season, before final finishing and fastening.

5/5/1 THE MYTH OF DUGOUT BUILDING WITH FIRE

There are some pointers to the use of fire in the hollowing process by native Americans in areas where resinous, highly inflammable trees were used (Roberts and Shackleton 1983:73, also see McGrail 1978:34). However, there is no authenticated evidence for the use of fire for hollowing out oak dugout boats in a European context, known to this author. The remains of ancient decay and the common black staining of oak in most west deposits have often been confused with evidence of charring by non-specialists (eg. Mackie 1984:132 writing of the manufacture of them Loch Doon 1 boat see below). There are several other more plausible reasons why fire was used by dugout builders and users and indeed is still in some parts of the world;

1/ Using fire to heat and render pliable, the sides of a dugout for expansion (eg. McGrail 1978:38, Tallec 1991:47, Petersen 2000:87, Goodburn 2000:222, Crumlin-Pedersen 2001 and 7/3/1 below).

2/ Using fire to singe off sharp slivers of wood to create a smooth finish (Axel Lindgren Native American dugout boatbuilder, Trinidad, California, Pers. Com. And direct observation 1991.).

3/ For ritual purification of an artefact (source as above and Cranstone 1971).

4/ Using fire on a clay hearth; possibly for onboard cooking, transporting a light and for flare fishing. Such hearths have been found in many mesolithic Danish dugout vessels (Christensen 1990).

Green oak's potential for burning away

Nearly all the dugout boat finds from Britain were built of oak which is slow burning and hard to ignite in large pieces, even when seasoned. Recent experiments have shown that fire removes green oak at an impractically slow rate. During the building of a replica of the Dark Age Loch Doon No.1 boat, for example, hollowing using a fanned fire of dry wood chips was attempted by determined students (fig. 44a). The result was singed eyebrows and less than 1mm burnt in over 1 1/2 hours of energetic flame fanning. Seaby recorded details of another, rather more strenuous, unsuccessful attempt to use fire in building an oak dugout boat reconstruction. His team even tried using bicycle driven bellows to force the fire to virtually no effect (Seaby 1989)!

5/5/2 PRIMARY WORKING- A PRACTICAL RECONSTRUCTION OF THE LIKELY PROCEDURES USED

Although traces of the initial stages of work in converting a log into a dugout boat or nautical timber can survive, they were not preserved in this case. However, it is possible to present a hypothetical picture of how this work was carried out based on critical use of three sources: the growing body of analysis of pre-Conquest woodworking in general: this author's practical experience of building seven dugout boats using Roman to medieval style hand tools: a critical evaluation of the copious, though often vague, ethnographic information.

5/5/3 WORK FORCE.

It is likely that the laborious early stages of the work would have been carried out with the help of friends and relatives, a practice commonly recorded in ethnographic accounts (Reynolds 1968:117, McGrail 1987:64, Axel Lindgren pers. com.). Practical experience, conversation with other modern dugout boatbuilders, and some ethnographic accounts suggest two reasons for sharing the workload. The first is practical, in that rapid working prevents the surface of the timber from drying out and becoming harder to work. Additionally, the greater the thickness of a section of green timber the more likely it is to develop damaging ‘shakes’. This phenomenon is a result of the differential tensions set up by the inside drying more slowly than the outside which thus shrinks more in a given time, and it is a particular problem with oak. Secondly, since being faced with several tons of natural green tree is a daunting experience at a human psychological level, working with a group, probably including older people more familiar with building dugouts, was likely to have been highly supportive (McGrail 1987:64). It would also have provided opportunities for valuable social and possibly ritual activity. Some form of group environment must also have formed the context for learning the craft of making a particular type of boat.

5/5/4 LIMITS ON THE SIZE OF THE WORK FORCE BUILDING THE CLAPTON BOAT

The relatively short length of the Clapton boat would have limited the work force to a maximum of three at any one time, although people might have worked in relays. For much of the time only two people could have worked together without risking injury from each others tools and flying debris, as was found during the experimental reconstruction of the shorter 7th century AD Loch Doon 1 boat (Lawrence 1992).

5/5/5 FELLING

The first stages of work involved the felling of a moderately large oak. As the use of saws for large scale woodworking was unknown in the 10th century in England (Goodburn 1992a:108, 1997b), we can assume that all this work was carried out with some type of felling axe(s). These would probably have been similar to the narrow bladed Wheeler type I axe (Wheeler 1927:24), the narrow blade and compact form being particularly suited to crosscutting work. Many recently examined non nautical timbers from Late Saxon London show clear narrow axe stop marks between 65 and 75mm wide on their crosscut and felled ends (eg. well and building posts from the 10th century Cheapside, CID90 site Goodburn 1999a:49). No felling 'drop', was visible on the finished craft. It is also possible that a wind felled tree was used as in the replica project, in which case the work would have started at the following stage.

5/5/6 LOPPING

Although there is one surviving example of the branches being left on a log whilst the work of hollowing the hull began (Ellmers 1973b:24), practical experience of building this shape of vessel and ethnographic sources suggest that in most cases the branches would have been lopped at an early stage so the precise shape and quality of the parent log could be assessed. In this way defects could sometimes be worked round or avoided. Practical experience with large oak logs shows that defects often lie buried around knots.

In non-nautical timbers in-the-round from pre-Conquest late Saxon London branches were clearly lopped with axes, probably the same as used for the felling work, with narrow blade widths of less than 90mm (Goodburn 1992a:109).

5/5/7 BUCKING

Next, the section of the parent tree stem to be used for the dugout hull had to be selected and 'bucked' (cut to length). Study of several hundred pre-Conquest timbers from various recent sites in the City of London has shown that bucking, and all cross-cutting was done with narrow bladed axes rather than saws (Goodburn 1992a:110), a practice documented elsewhere in Northern Europe at the time as at Hedeby (Elsner Undated:61). We can assume, therefore, that this was probably the procedure used for the Clapton boat. The bucking cuts were probably so arranged that some of the slope of the bow and stern was cut at the same time. Any evidence for barking the parent log had been lost.

5/5/8 MARKING OUT AND ORIENTATION WITHIN THE LOG

It is difficult to reconstruct the procedure for the initial marking out of the parent log in the case of the Clapton boat, as all evidence of this stage failed to survive. However, this stage is documented as an important point in the work of recent dugout builders governed by traditional 'rules of thumb' (McGrail 1987:61, Leshikar 1975:48). One might guess that the log was used with its widest dimension horizontal to obtain the greatest beam for the finished boat.

5/5/9 ROUGHING OUT

The basic shape of the hull would then have had to be formed by roughly hewing and splitting away unwanted timber. It is clear that this would have been done using some form of the 'notch and chop' technique, universal in all large scale woodworking world-wide (eg. Reynolds 1968:117, Leshikar 1975:48) and a well documented late Saxon technique (Goodburn 1992a:112). Axes would have been used to cut grooves and, possibly aided by the use of wedges, to split off large chunks of timber (fig. 44b). It is possible to remove large fragments of oak weighing several kilos just with a moderate sized Saxon style narrow felling axe. Using wedges even larger blocks of waste can be removed if the grain is straight enough to allow it. In the case of the original and replica Clapton vessels the grain was somewhat spiralled and knotty, preventing the splitting away of very large pieces. This added considerably to the time taken to build the replica vessel.

Both the outside and the inside of the hull were almost certainly shaped by some form of this basic technique, although as the hollowing progressed, cutting the grooves inside becomes increasingly awkward (Leshikar 1975:49, McGrail 1978:32, Goodburn and Redknap 1988:19 Axel Lindgren Pers Com.). The axe used to cut the internal grooves has to be used at a steep angle, so only one corner of the blade digs in this leaves distinctive marks often visible in the bottom of a finished dugout vessel. For example the unfinished 7th century Loch Doon No.1 boat and the completed 13th century Wasdale Beck boat have these distinctive marks (fig.45c, and Hirte 1997:163).

Order of shaping the hull, outside or inside first?

Whether the bottom or top of the vessel was shaped first can not be established, but in the case of the replica project, the bottom and sides were shaped first. However, the apparent misalignment of the thickness gauge holes in the bottom of the original hull may be suggestive of the order of construction (see 5/7 below).

5/6 EVIDENCE FOR SECONDARY WORKING (trimming and finishing)

The later phases of work on this vessel left more tangible traces in the form of distinct toolmarks. They survived best inside the hull; experience with the Ravensbourne shows that the outside of such a vessel rapidly becomes abraded in use, thus removing most external toolmarks. The abrasion of the outside is caused by the rubbing of poles, paddles and mooring stakes and by going aground on abrasive surfaces. A summary of the varied toolmark evidence is presented below.

5/6/1 TOOLMARKS AND TOOL KITS

It was possible to reconstruct much of the tool kit that the original builders used in the later stages of the construction of this boat. The six recorded different types of 'stop marks' are negative outlines of the tool edges or parts thereof (Goodburn 1989, Append. 5). In addition, the length, orientation and depth of whole mark or 'facet' can provide evidence of the hafting of the tool, the force and degree of care with which it was used and the 'greenness' of the timber worked. For the sake of brevity the marks are listed below with suggestions concerning the types of tools and work that produced them. The fine ridges or 'signatures' peculiar to the distinctive damage of one individual tool edge, did not quite survive in this case, thus, individual tools could not be distinguished although distinct types of tools could.

1/ The marks of an axe

Clear, slightly curved shallow facets of a maximum width of 75mm were found on the bulkhead, and a 'flat' of slightly greater width (c.80mm) was found on the outside of the hull. These appear to have been left by a thin bladed hatchet or small axe possible ground on one side only (fig.46). This tool was used to finish the sides of the hull outside, the bulkhead and probably the upper parts of the inside. The axe may have been rather similar to the example found in the Anglian Harbuck hoard from Durham (Fenwick ed. 1978:186).

2/ Marks of an adze

Slightly curving facets with a maximum width of 70mm were found in the middle of the bottom inside. These must have been made by an adze (fig. 47), since an axe could not have been manipulated in the space between the upstanding sides. This tool was used to finish the bottom inside, and probably also outside with the hull inverted, as using an axe horizontally is very awkward. The adze(s) used may have resembled the medium-sized Anglo-Scandinavian find from Thetford, Norfolk (Wilson 1968:145).

3/ The marks of a gouge adze

In the area where the bottom of the boat turns into the sides the 'turn of the bilge' concave facets about 38mm wide were found. These appear to have been made with a small gouge adze (fig.48). This tool was ideally adapted to trimming and shaping tightly concave surfaces. Such tools have been found in Viking contexts in Scandinavia in a simple socketed form (Christensen 1985:236). The photographs of the turn of the bilge area of the dugout Haddeby 2 show similar marks but in this case the gouge adze appears to have been wider at c. 45mm (Hirte 1997:153). The stepped marks that result from the use of a driven gouge were not recorded and the depth of the hull would have made it almost impossible to use an 'inshave', such as has been excavated in Viking York (J.Spriggs Pers. Com.).

4/ Traces of the use of three augers

Three augers were used; one of about 2Omm diameter, to drill the bow strap treenail holes, another of about 23mm for the thickness gauge holes, and one of about 40-45mm for the large hole in the bow. This hole is now much more visible, since post-excavation distortion has opened up the area. This last auger would have been unusually large possibly quite a rare tool, as bored holes of this size are only occasionally found in contemporary woodwork.

The tool mark character and 'quality of finish'

Although the boat cannot be classified as roughly finished, it is clear from the depth and clarity of the facets that the builders were not intent on achieving a perfectly smooth finish. No decorative features such as scratch mouldings or relief carving survived on the original boat, though they are known from contemporary plank boat finds and some dugout vessels (McGrail 1978,134, Goodburn 1994a). The possible significance of the simplicity of finish of pre-Conquest vessels from England is discussed in Chapter 9.

It is quite clear that a few other simple tools would also have been required to build the boat. Experience building the replica of the vessel suggests that a heavier, thicker-bladed narrow axe would probably have been used in the early stages of the work. It is also clear that a heavy wooden maul and wedges could have been used to remove some large blocks of waste, where the grain would allow.

Charcoal, chalk or ochre-based pigments may have been used for marking out during the finishing stages of work. We found experimentally that soft charcoal is particularly suitable for marking wet, sappy, oak timber, but it would leave no archaeological trace (Goodburn and Redknap 1988:10l, also Bill and Johansson 1987:35). Levers, skids and possibly rope would also have been necessary for haulage from the building site to the waterside.

5/7 SYMMETRY AND CHECKING THE FINAL SHAPE THICKNESS GAUGE HOLES AND OTHER MEANS

The two holes in the bottom of the vessel were clearly bored to allow the builders to gauge the thickness of the bottom during the hollowing. These holes are slightly misaligned in relation to the centre line of the original vessel, possibly because the builders bored them through an unfinished bottom. Symmetry at this stage was not accurately maintained. Indeed, the slight but clear asymmetry in plan of the original vessel shows that the builders were working either to the shape of the parent log or, less likely, to produce a deliberately asymmetrical vessel (like a gondola or proa hull) that runs true when propelled from one side only.

After boring the thickness gauge holes the now much lighter, hull could have been rolled over. Only three people were needed to roll the replica hull over at this stage. Then the process of fairing both the inside and outside could begin, probably guided by feeling with opposed finger tips and sighting.

The bottom of the original craft was left surprisingly thick (c.lOOmm, 4") and heavy. Although this would have had some functional benefits in terms of stability, but would have made portaging more difficult. The thickness also limits carrying capacity as the extra timber displaces water that could have been displaced by cargo in a lighter vessel. Most surviving medieval dugout finds from England were much more lightly built.

It is likely that the hull was rolled on to a simple building platform of at least two small logs as this would raise it to a more convenient working height and prevent tool-blunting dirt sticking to the hull (McGrail 1978:30). The weight of an oak dugout of this form renders it easy to wedge firm, with out it bouncing around.

5/8 CONTROLLING SEASONING

The ethnographic sources and experimental experience indicate that controlling the seasoning of the green, freshly-finished hull would have been important (McGrail 1978:34). Oak is particularly vulnerable to splitting and distortion when in the form of a boxed-heart whole timber, or tangentially faced section. After the final trimming, the hull would have started to season causing it to loose weight, shrink, split and distort through loss of sap. To slow and reduce this process the hull must have been smeared with fatty or oily material and kept out of the sun and wind as much as possible. Alternatively, it may be that a period of submergence in water followed final trimming or a stage just prior to it. Partly-worked timbers for planked boats of this period have been found deliberately submerged and it has been suggested that this aids seasoning in some way (eg. the Eigg stem, McGrail 1978:34). Storage of roughed out timbers in submerged locations is also known from two later medieval English boatyard sites at Poole Foundry, and Kingston bridge (Watkins 1994, 8/2/2 below). It is also a documented traditional practice in recent times in western Norway and worthy of more experimental research (Crumlin-Pedersen Pers Com., Vadstrup 1997:92). The few finds of unfinished dugouts, such as the 7th century Loch Doon 1 boat are perhaps suggestive of abandonment during submergence for slowing seasoning. There is also some evidence that dugout vessels were sometimes deliberately sunk by their owners during long periods of disuse to prevent excessive drying out, and possible theft or damage by hostile groups (eg.Newsom and Purdy 1990:177).

In the replica Ravensbourne, animal fats were used to reduce seasoning distortion and surface splitting, untreated surfaces were seen to develop splits quickly in sunny, windy early spring weather, before the trees were in full leaf. The closing of the woodland canopy in mid may, seemed to increase humidity and reduce over rapid drying, despite a rise in average temperature.

5/9 EVIDENCE FOR LIFE HISTORY

Practical experience of the seasoning and weathering of oak timbers with the pith in suggests that at least one large split is likely to develop towards each end of the timber. This was the case in the Clapton boat, and was countered by the fastening of a strap across the bow of the vessel (fig.40). In the replica vessel, similar splitting took place at the bow end within a year of being built. The central bulkhead also split in the replica in the same way as it had in the original vessel. However, none of the damage to the original vessel was such that it would have prevented its use. In the replica it was found that after about 4 years a twist had developed in the hull, perhaps as a result of the spiral grain of the log. This twist of c. 10 degrees from bow to stern noticeably reduced the carrying capacity, as it reduced the freeboard on one side.

5/9/1 CONSEQUENT CHANGES IN HULL SHAPE

McGrail was the first to realise the great importance of the shrinkage of waterlogged dugout boat finds after their exposure, and the effects this has on attempts to reconstruct their original proportions. He developed the concept of a 'shrinkage factor' which relies on the tendency of timber to shrink much more across its width and thickness than its length (McGrail 1978:23). Thus, the average degree of distortion of any hole from a perfect circle was thought to be a guide to the overall shrinkage of a dugout boat as a whole, principally across its depth and width (fig.50). However, there are several reasons why this concept is not totally reliable in practice (Goodburn 1987:218 and below):

1/ It assumes a level of homogeneity in decayed oak timber which is very rarely the case in practice, particularly in logs used for dugout boat building. The presence of knots, varying ring width and the varying orientation of different parts of the hull of a dugout vessel result in unpredictably variable rates of shrinkage in green timber and degraded ancient waterlogged timber.

2/ Any variation in the state of seasoning of different parts of a vessel, when it was bored, during the building process will result in different degrees of distortion in the holes. In practice, the upper sides of a dugout vessel become far more seasoned during building than the lower, thicker parts of the vessel less exposed to the drying wind.

3/ Holes bored for fastenings are distorted by the driving of the fastenings. In the case of wedged treenails, the wedging process causes further distortion.

4/ The preparation of countersink holes for treenail heads may also complicate measurements.

5/ The working of a fastening during the use of the vessel can cause differential distortion in its hole. The tightening up (re-rivetting or re-wedging) of such a fastening can also cause distortion.

6/ Post-depositional factors such as, differential decay and compression due to the weight of overburden are often seen to have caused substantial variation in otherwise similar-sized fastening holes.

7/ Post-excavation factors such as the differential drying of parts of a vessel exposed for different lengths of time can also cause irregular distortion of holes.

8/ Conservation procedures also cause variable distortion to fastening holes.

9/ The practical difficulties of measuring accurately two axis of each hole, due to their varying erosion, is considerable in this writers experience (fig.50).

10/ Many dugout vessels have few holes in them which makes obtaining meaningful average figures impossible.

For all the forgoing reasons and a lack of time in the field stages of rescue archaeology this approach has not been used in this study.

5/9/2 MEASURED DISTORTION IN REPLICA DUGOUT VESSELS EXPOSES A SURPRISING TREND

Observations on the behaviour of several oak dugout replica vessels during seasoning and use have revealed a very surprising trend. The oak hulls actually shrink little in overall beam, in fact they often become wider. This observation has significant implications for the reconstruction of the original dimensions of dugout boat finds, their parent trees, the builders original intentions and assessments of their performance. For example, the maximum beam of the Ravensbourne replica was measured at the central bulkhead at three intervals after finishing the construction in May 1988. It was found to have increased in beam slightly over four years, rather than decreased as might have reasonably been expected (fig.51). The vessel was usually stored in shady spots outside, some of the time afloat, but with a period inside a museum where the bilge was normally kept damp. The dimensions recorded are tabulated below.

Date.	Beam at bulkhead.	Width of split in bulkhead
5/5/88	0.670m	3mm
23/7/88	-	15mm
1/7/89	0.670m	20mm
11/8/92	0.695m	40mm

The reason for this tendency to change width irregularly is that the main drying shakes often allow the sides of a vessel to move out, as it seasons, propelled by internal stresses.

In archaeological finds the 'growth in beam' tendency may be accentuated by overburden pressures and often over rapid drying of the waterlogged hulls. For example, the bow half of the Loch Doon No.1 boat has clearly become over 0.12m wider than when originally constructed (Mackie 1984:131). McGrail noted the likelyhood of this type of distortion at one point in his gazetteer (1978:266), but does not develop the point.

5/10 TIME TAKEN TO BUILD THE VESSEL, OR 'LABOUR INVESTMENT'

One of the motivations for the building of a replica of the Clapton boat was that the project might provide useful data on the man-hours it would have taken to build the original vessel.

It is clear to this writer that few, if any, ethnographic accounts are reliable in the area of 'man/days' used to build vessels since too many details are unrecorded or improbable (see McGrail 1978:35). There are a number of reasons why this is. Firstly, the observers would have to be in constant attendance, often for several weeks, on one project. Secondly the builders may have had their own motives for maintaining the 'mysteries' of their craft, a tendency known even in modern, traditionally trained, British boat builders. Thirdly few observers appear to have had any practical first-hand knowledge of such work and could thus, have been easily hoodwinked or confused by informers, with whom there would generally have been translation difficulties in any case. Of key importance is that fact that none of the accounts deal with building a dugout of comparatively tough oak NW European oak (*Quercus petraea or robur).*

Problems with the uncritical use of experimental data

The Ravensbourne project was also a training exercise for archaeology students and nautical archaeologists (including this writer) in basic aspects of ancient woodworking. No pool of experienced workers exists in Britain akin to that which exists in Denmark, after more than thirty years of experimental work (Vadstrup 1984). It soon became apparent that the figures recorded in the project logbook (Append.4), for the time taken to carry out various stages of the building were often of little value for calculating late pre-Conquest work rates. It was clear that work rates varied by a factor of as much as ten times between individuals. Therefore the time data recorded has to be skewed in favour of the work rates of the more able to obtain an estimate for the time taken by the original builders for the work. The Replica Ravensbourne took approximately 45 61/2hr person/days to build, but this figure is of limited significance, as explained above. This factor of the lack of craftsmanship of modern experimenters is important (Christensen 1986:155), but after seven successful oak dugout building projects estimates now clearly have more validity.

5/10/1 IMPROVED ESTIMATES OF THE LABOUR INVESTMENT REQUIRED TO BUILD THE CLAPTON DUGOUT BOAT

More recent oak dugout building experiments have been completed in much shorter times and have provided a more balanced view of how long the process may have originally taken. The Loch Doon No.1 boat replica (a very similar, if slightly simpler, vessel) was built in 1991 in about 10 days, with one to three people working at any one time. Hewing large oak timbers is extremely hard work even for the fittest workers rest periods have to be allowed for. With these provisos, it is suggested that perhaps two or three people could have built the original Clapton dugout boat in two to three weeks, with frequent rest days. This might amount to about 10-12 days actual work-,(c.20/person days?). These days would probably have been short days in winter or early spring, both to fit in with annual work cycles and the heaviness of the work. The longer hotter days of late spring and summer would have made the work harder and tend to season the timber too fast. It is likely that the most skilled woodworker would have worked alone on the final trimming and smoothing of the hull.

Very recently it has been possible to experiment with building a slightly larger dugout boat from a cleft half oak log. The reconstruction was based on the Amberley 3 find from the R. Arun in W. Sussex (McGrail 1978:146). The find was C14 dated to the 8th century AD. The vessel had an original length of c. 4.5m with a beam of c 0.65m. This project was accomplished in hot summer weather in 8 days using a Saxon style tool kit with the workforce of varied skill levels. Two to four people worked on the vessel at any one time and the total person days used was approximately 24 directly on the hull itself. If this figure is skewed in favour of the work rates of the more experience workers the person/days taken would have been nearer 15-20. The work was carried out in August 2001 at the Weald and Downland Open Air Museum where the need to interpret the work for the public and the heat inevitably caused some delays.

5/11 AGE OF THE VESSEL WHEN ABANDONED

It is clear that the toolmarks on the outside of the hull had been much worn, possibly by rubbing against river banks, mooring stakes, and perhaps jetty piles. The marks on the inside of the vessel were little abraded (less than in the replica at about three years old). This suggests that the Clapton boat was almost certainly less than five years old when abandoned and enveloped in protective waterlogged silt.

5/12 SUMMARY

This chapter covered the practical investigation of a small, simple pre-Conquest dugout boat. Here the vessel is seen as representative of a numerous class of vessel that has been overlooked in some accounts of medieval boatbuilding. The types of raw materials used by the original builders were reconstructed. They comprised a local oak about 0.8m in diameter with a short, fairly knotty bole, less than 4m long. The bungs and fastenings were probably made from 'offcuts'. However, pine tar, a foreign import, was also used illustrating that even the builders of such a humble vessel could tap an international trade network to some extent. Evidence for the methods and techniques of building were described in detail. The surviving toolmarks indicated that a tool kit of at least six, probably seven, metal tools were used to build her; a small axe, a gouge adze, an adze, a larger felling axe, and three augers. The various possible strategies for building the craft were discussed drawing on experimental research and a critical use of ethnographic sources. The myth of hollowing oak dugouts with fire was examined critically. The experimental reconstruction of the Clapton boat and other similar dugout craft informed a discussion on the probable workforce and labour investment required to build this vessel. Three would have been the maximum number of people who could have worked at any one time, and it is suggested that the original boat would have taken very approximately 20 person/days to build. This work period would probably have been spread over a minimum of three weeks. Evidence for the life history of the craft was also examined which suggested that the Clapton boat probably was less than five years old when abandoned. New strands of evidence bearing on the typical patterns of shrinkage and distortion to be expected in oak dugout vessels were also discussed, and existing views of hypothetical shrinkage factors rejected.

Additionally, aspects of the performance of the vessel were reconstructed, for example, it would have been able to carry a load of about 200kg. Initial trials of the replica have also shown that the performance and usefulness of the craft had previously been under-estimated.

The wider issues raised by the analysis such as; the socio-economic role of the vessel, the place of this type of boatbuilding in the local Late Saxon economy and environment have not been dealt with in detail. These issues will be discussed in comparison with those relating to planked vessel building in chapter 9. The modest raw materials and labour investment represented by this craft will also be compared with those required for the building of a more complex later medieval extended-dugout in chapter 6.

6/ THE KENTMERE I EXTENDED DUGOUT: A SMALL MEDIEVAL LAKE BOAT

This chapter contains a detailed description and practical analysis of a medieval extended dugout boat from N.W. England. In the context of this study it is treated as an intermediary form between the constructional complexity of fully planked craft (Chapt.7) and the comparative simplicity of basic dugout boat such as the Clapton boat (chapt.5).

6/1 BACKGROUND

Excavation

The remains of the vessel were found during the excavation of the bed of a silted up and artificially drained lake or 'mere' in 1955 (Wilson 1966). The findspot lies in an upland region dominated by hills, mountains, 'meres' (lakes) and small rivers (fig. 52).

It was immediately realised that it was an unusual and important vessel and a number of archaeologists became involved in its excavation and initial recording, including D.Wilson later to become director of the British Museum. However, it is clear from correspondence and photographs held by the National Maritime Museum that the find was somewhat disturbed before scale drawings could be made (fig. 53a).

Summary of the post-excavation treatment of the find

After the excavation the dugout base was gently lifted with rope strops and with the other timbers covered with sacking and bracken and dried slowly. All the elements were then alum treated (fig. 53). Later much of the vessel was coated with Araldite resin (McGrail 1978:223). Attempts were made to reconstruct the stabilised, dismantled timbers of the hull in the 1960's at the National Maritime

Museum, Greenwich. However, the differential shrinkage and distortion of various elements made the task physically impossible (fig.54). Some alterations were made to the original timbers at this time, for example, several extra holes were drilled in the planking for temporary fastenings. The vast majority of the boat timbers survive relatively intact and are held in store by the National Maritime Museum in London.

6/2 WILSON'S DESCRIPTION OF THE VESSEL

Wilson described the vessel as being an oak 'dug-out canoe' 4.25m long and 0.61m wide, with a flat bottom, rounded stern and slightly pointed 'prow', extended on either side with five oak 'wash strakes' (Wilson 1966:81, fig. 55). It is clear that the drawings presented by him cannot be taken as wholly accurate it is probable that they were intended as a representative view a 'best fit' following the earlier disturbance. A number of details are not shown correctly, such as the 'rowlock plank' (compare figs. 55 with 57). In addition it is not clear which timbers were actually still in situ when recorded.

The added strakes were each made in two pieces scarfed together and were fastened with round-headed, square shank nails. Below them a 'bilge keel' was fastened on each side. The planking was described as 'split and adzed into shape' (Wilson 1966:82). Four naturally grown crooks were used for ribs, fastened down to the bottom of the dugout with square headed treenails driven into shallow holes. The boat also had plank thwarts, and a square 'well-worn' rowlock plank survived, treenailed to one sheerstrake.

The rest of Wilson's paper was largely devoted to a discussion of the place of extended dugout vessels as evolutionary links between dugout boats and more complex plank built craft. However, the dating of the Kentmere 1 vessel to later medieval times (see below) seems to render this line of reasoning redundant. Despite this, the paper was very important in drawing to the attention of archaeologists and historians the evidence for widespread use of dugout vessels of various types in medieval Britain.

6/3 MORE RECENT ANALYSIS OF ASPECTS OF KENTMERE 1 BY MCGRAIL et al.

Since the publication of Wilson's account of the find limited re-investigations of the vessel were made by the Archaeological Research Centre of the National Maritime Museum which closed down shortly afterwards. McGrail noted that in 1978 that the remains of the boat were to be subject to 're-assessing' (McGrail 1978:224), and some results of this re-assessment have been published (eg. McGrail 1978:223-225, 1981:28, and 1987:75). Some new information was bought to light by this work, as well as some new interpretations of the vessel's form; these are annotated below.

1. The boat had apparently 'grown 5cm' in length to about 4.30m.

2. Several wood species identifications had been made which are listed below (McGrail 1978:224).

a) The bilge timbers were considered to be oak *'Quercus sp.'*.

b) Two of the treenails in the bottom were identified as oak *'Quercus sp.'*

c) The grown ribs were identified as birch *'Betula sp.'*.

d) The oarlock plank was found to be ash *'Fraxinus sp.'*

e) The central thwart was identified as ash, the end thwarts oak.

Additionally all the planking was described as 'radially split' (McGrail 1978:224, and 1987:75). The lap fastenings were described as '6mm diameter square shank, iron nails clenched over round roves' (McGrail 1987:75).

Significantly, the unusual form of the dugout hull was attributed to the repair of a dugout where the central section had 'rotted' or been 'damaged' (McGrail 1981:29).

Some up dating of information on the boat find was also provided by Hutchinson in 1994, where she notes similar details to the above but includes new observations such as the ribs were of '.grown oak crooks..' and the nails used at the lands were hammered over on the inside (Hutchinson 1994a:122). During the re-investigation of the vessel for this study no evidence was found for either of the above (see below).

6/4 DATING EVIDENCE

Samples from the vessel have been radio-carbon dated to AD 1320 _+ 130 years (Wilson 1966:81) or 650BP _+120 (=c 1300 AD, McGrail 1978:224). It has not been stated from which part of the boat, how or when the samples were taken. This is of very considerable importance as such a date would vary by perhaps 200 years depending on where the sample was taken from in the main log base or oak planking.

6/5 RE-RECORDING OF THE REMAINS OF THE VESSEL FOR THIS STUDY

It was clear that there were still some ambiguous areas in our understanding of this vessel. On a visit to assess the current state of the remains at the National Maritime Museum it became apparent that detailed, but selective, re-recording would be useful for the purposes of this study. Some important new evidence about the dimensions and form of the vessel and its construction and raw materials came to light, during study visits in 1988 and 89.

6/6 BUILDING AN EXPERIMENTAL REPLICA.

As part of this in-depth reassessment a project is underway to build an experimental replica of the vessel with appropriate tools and materials. This un funded experimental work has been stalled due to the interference of other work and family commitments and is now (2002) about half complete (Append.4). Despite this the replica project has been able to inform the analysis of the original find and some more general aspects of medieval boatbuilding practice relevant to chapters 5 and 7 (Append. 4).

6/7 A SYSTEMATICALLY RECONSIDERED HULL AND POSSIBLE ROLES FOR THE VESSEL

A larger reconstructed beam

The remnants of the ribs of the vessel were recorded and the information combined with the flare evident in the lower hull, suggests that the extended hull originally had a maximum beam of c. 0.90-0.95m. This is considerably wider than what would have been possible within the confines of the parent tree used for the dugout base (fig. 56).

Theoretically increased performance

The additional beam would have had important consequences for the performance of the boat. Its load-carrying capacity, resistance to swamping and loaded stability would have been considerably increased. Experiment shows that the building of the flared dugout base involves considerably greater labour than that required for other more common dugout hull forms, such as the flattened 'U' shape of the Clapton boat (Chapt. 5). Therefore, it is now suggested that the boat was not the result of idiosyncratic repairs to a damaged rotten dugout (cf. McGrail 1981:29, 1987:75) but the product of deliberate decision making by the builder(s). The builder(s) appear to have wanted a more capacious craft with greater loaded stability than a simple dugout would have provided from the oaks available to them.

A slightly rockered bow

The bow end of the boat had not been supported for several years on its storage trolley but was still found to rise slightly. The slight upward curve starts at about 1.10m from the extremity of the bow (fig. 57) and would appear to be a deliberate original feature. The upward 'rocker' would have eased the passage of the boat through disturbed water and facilitated beaching and launching.

Number of strakes each side?

Wilson reconstructed the boat as having had five strakes on each side (Wilson 1966:83) and this has been generally accepted. However, there is considerable evidence to suggest that this may not have been the case:

1/ Several detailed site photographs show what appear to be five strakes on the starboard side and four on the port.

2/ V. Fenwick kindly drew my attention to rough sketches by a Mrs. M. Garnett, dated '10th May 1955' which are annotated 'four strakes laid flat'. Copies of the sketches are held by the National Maritime Museum. The originals were made on the fifth day after the find was discovered.

3/ When the plank widths and laps are added together it is extremely difficult to accommodate them within the space allowed by the dimensions of the rib arms and depth of the bow and stern, even allowing c. 20% for shrinkage.

4/ Possibly related, is the fact that the lap on the port side of the dugout base is 80-90mm wide whereas the starboard lap is only 70mm.

Explaining the unusual strake pattern

It is therefore reasonable to make the surprising suggestion that there were only four 'proper' strakes as seen on site by Mrs Garnett. On the slightly concave port side of the hull a packing piece or 'stealer' had apparently been added to make the vessel wider and more symmetrical before the main planking up began (fig. 56). This feature would have given the appearance of five strakes on that side. Although the evidence is clearly still a little ambiguous on this point, the survival of an 80mm wide batten-like plank fragment, which could have served as such a packing piece, may support the contention. Due to the time elapsed since the excavation D. Wilson cannot now verify or refute this suggestion (D.Wilson Pers Com.). The hypothetical reconstruction with four strakes was used as the model for the replica project where the parent tree used was a little straighter and the hull could be fashioned without any need for compensating for a substantial bend in the parent log.

The revised dimensions

The re-recording of the vessel has enabled the following revision of the published hull dimensions, which are listed below.

The overall length = c. 4.32m (a loose modern section at the stern making accurate measurement impossible)
The beam of the dugout body midships = 0.47m
The beam of the dugout body at the stern = 0.52m
The beam of the dugout body at the bow = 0.44m

It is also possible to build on the practical experience of ancient and replica dugout hull distortion to derive the following approximate original dimensions (see fig. 51).

Overall length about 4.33m
Maximum beam to outside planking midships about 0.92m

Maximum beam of dugout base midships between 0.55-0.47m
Depth midships including planking about 0.55-0.60m

A role for the craft; and notes on potential performance

It is difficult to reconstruct the role this craft had in the community in which it was used, as there has not been a concerted archaeological and paleo-environmental campaign of research in the remote find region. The boat has also not yet been subject to theoretical or replica performance trials. However, it can be suggested that if the reconstruction shown in figure 56 is moderately accurate then the original vessel would have had considerable utility. The presence of three thwarts in the craft suggests that it was intended to carry 3 people, at least part of the time, since the thwarts have only a modest structural function.

It may perhaps, have been able to carry about twice the cargo of the Clapton boat. We can make an informed guess that the load capacity would have been over 400kg with adequate freeboard for lake use in calm weather. This boat would also have been able to travel faster than the Clapton boat, particularly in deep water, as it was equipped to be rowed. The comparatively lighter, narrower lower hull, and longer hull would also have been a factor here. However, the narrow bottom and stabiliser timbers indicate that it was not particularly stable with a modest load. Indeed the use of stabiliser logs implies that when lightly or partially loaded the boat would be tender initially, although hard to actually capsize. There can be little doubt in this case that the blunter wider end was the stern and the end with the stem hewn in solid, the bow. The flat bottom, slightly rockered bow, and perforated hewn forefoot would have facilitated beaching.

In sum, this boat can be seen as a general purpose craft, perhaps belonging to a local farm household, capable of carrying people, goods and even small livestock across and along the extinct mere. It could have been propelled easily by one person using small oars and probably a pole in shallows.

6/8 EVIDENCE FOR THE RAW MATERIALS USED AND INITIAL WORKING OF THOSE USED IN THE MAIN BODY OF THE HULL

Raw materials

Using the methods described in Appendix 2 it is possible to reconstruct the timber raw materials used to build the vessel. The main body of the hull was hewn from a moderately large, slightly bent oak (*Quercus robur or petraea sp.*). Some of the bend in the original tree was apparently left in the finished hull (figs. 53b, 57). Allowing about 0.5-0.6m for the felling cut, the bole of the parent tree must have started to branch out at about 2.8-3m from the ground (fig. 56b). The branches would have been of medium size and fairly evenly spread out up the stem of the tree, which would have continued further in its usable length. As traces of decayed sapwood appear to survive at the top of the bow and stern and on the extremities of the bottom of the middle hull, the approximate diameter of the parent log can be reconstructed with some confidence. The parent tree must have been about 0.6-0.7m in diameter at chest height, and perhaps 120-200 years old. The general characteristics of this hypothetical tree suggest that it grew in moderately open woodland, or on a woodland edge. The slight bend in the bole may indicate that it grew on a slope (fig. 56b, and 58).

Initial working

No clear evidence of the methods used for felling, bucking, lopping or barking was found for any of the components of the boat, but it is probably a safe working assumption to suggest that these early stages in the work were carried out with felling axes as described in 5/5, above.

No clear evidence survived for the methods or tools used to rough-out the dugout base of the vessel. However, as the notch and chop technique of hewing and splitting away waste was well known in medieval woodworking as a whole, and was used in other dugout boat finds found in NW Britain eg. the Loch Doon 1, and Wasdale boats (Goodburn 1992a:113, and Chapt.5/5), it is assumed here that some form of this method was used. For the replica the following approach was used. The hull base and ends were roughed out first by notch and chop techniques using felling type axes. This was followed by initial smoothing and trimming with both axes and adzes. In practice, a very great deal of oak heartwood had to be removed from the outside of the vessel demonstrating that the flaring shape was deliberately, laboriously and wastefully sought.

6/9 RAW MATERIALS AND CONVERSION TYPES OF THE PLANKING

All the surviving boards making up the narrow clinker strakes of the hull extension are of oak. The lower strakes on each side were of radially cleft and hewn narrow boards (fig. 59a, and b). Occasional knots were found in some boards. It is now impossible to reassemble all the rather featureless lower boards coherently, due to the differential distortion and erratic labelling. The narrow boards now vary from 150-100mm in width and 25-18mm in thickness. With an allowance for shrinkage the original dimensions might have been approximately 29-21mm thick by 160-110mm wide.

However, it is clear that, the broader oak sheer strakes were not radially cleft as has been recorded, but were tangentially-faced, rather knotty planks (cf. McGrail 1987:75). These fragments are now too eroded to distinguish whether they were cleft and hewn or sawn out (fig. 59c). They are now 17-20mm in thickness and 160-170mm in width, and no clear traces of sapwood were found along the plank edges.

Parent logs for the radially cleft boards

The parent log(s) for the narrow radially cleft boards must have been about 2.5m long and 0.45-0.55m in diameter, straight grained and largely knot free. Such relatively short, straight logs can be found in the butt lengths of carefully selected, English woodland standard oaks today (fig. 58b). Short lengths of high quality radially cleft oak board are well known to have been traded over considerable distances in late medieval times, from the SE Baltic to London for example (Tyers 1991), as well as shorter distances (Chapts. 7 and 8). It is therefore possible that these narrow boards were made by 'clovyers' elsewhere and traded-in, tree-ring study might verify or refute this suggestion in future. Unfortunately tree-ring sampling may not now be possible. If local oak was used it would have to have grown in a reasonably sheltered valley location (see Salzman 1952:244, for a 1391 mention of 'Kendal' boards). The wider fore and after thwarts were also of radially cleft oak, and if they were made from the same parent log only the widest clove boards could have been used for them. It may be more likely that they were cut down from barrel head pieces, which can contain short wide boards of high quality. The recycling of barrel or more properly 'cask' timber is well known from medieval London and elsewhere and might be particularly sought after in an area with little large straight oak timber.

Possible explanations for the extreme narrowness of the radially cleft boards

The atypical narrowness of the radially cleft side strakes might be explained if we considered them to have been originally produced for another purpose. It is quite possible, if not probable, that they were made for use as fence pales, gate bars, barrel staves or possibly staves for use in some type of building work. Examples of medieval oak fence pales have been excavated in London and have broadly similar proportions (Goodburn unpub 1992).

6/10 NOTES ON THE EXPERIMENTAL PRODUCTION OF RADIALLY CLEFT BOARDS

A fundamental aim of the replica building project was to gain first hand, detailed knowledge of the production of radially cleft oak boards. The production of cleft oak boards larger than barrel staves is a lost craft in Europe since perhaps the 18th century (Vadstrup 1997:88), gradually being rediscovered by archaeological experimenters. It was a basic requirement for pre-Conquest and most medieval and 16th century clinker boatbuilding in England and most of N.W. Europe. The first recent experimenters to gain a good working knowledge of the technique were Danish and principally concerned with building reconstructions of small Viking period vessels (Crumlin-Pedersen 1985). Gradually building on experience, Danish experimenters are now able to produce wide, regular boards getting perhaps 16-20 boards from a straight-grained, oak log about 1m in diameter (Vadstrup 1997:90). However, they generally use many large steel wedges and sledge hammers, tools which have not left documented traces on English cleft board finds of pre-Conquest or medieval date. In practice iron wedges tend to leave pressure marks on the 'as-cleft' surfaces of pales and boards and these have not been found yet by this writer when examining undressed surfaces. However, the possibility of using an old axe or possibly an axe-like hafted wedge can not be ruled out. It has been suggested by Crumlin-Pedersen that such tools were probably used to make shipboard for three reasons. The first reason is that metal wedges make the work easier. The second is the lead given by a French manuscript image of the 12th century AD showing two monks splitting a small knotty log using an axe-like tool hit with a large mallet or maul. Finally it is thought that one of the tools from the famous Viking period Mastermyr chest hoard was a hafted wedge rather than an axe (Olsen and Crumlin-Pedersen 1968:160).

For making the radially cleft boards for the Kentmere boat and other projects hardwood wedges and wooden mauls and have been successfully used to achieve 1/32nd splits in logs up to 3m long and up to c. 0.9m in diameter (figs. 60 and 80, and 7/6/4). The same tools have been used to cleave larger logs in half up to 1.3 m butt diameter and 10m long, In this work the author was initially tutored by R. Darrah, who is probably the leading British experimenter in this field. (see Append. 4). The basic approach can be summarised here as follows (see fig. 60);

1/ The selection of a straight-grained, fairly knot-free, green oak log in diameter about 3x the width of the desired board, often 0.8-1.1m diameter. This allows the majority of the feather edge and sapwood to be cut off. Usually only the lowest log in a parent tree can be used.

2/ The splitting in half of the log with many wooden wedges driven with large mauls. Small starting splits may be made initially by driving a metal wedge or old axe, and slivers of wood crossing the split may be cut with a thin bladed hachet or 'slick' (a long bladed chisel).

3/ The carefully splitting down of each half log closely following the medullary rays of the timber into 1/4s, 1/8s and 1/16s sections.

4/ Given straight enough timber the 1/16th split can then have its feather edge hewn off and be split into 1/32s. A few failures are to be expected, but later medieval accounts show that 30 boards a tree was the average yield of English clovyers (Chapt. 8/1).

Further experimental work and reading (eg. Edlin 1949:90) has revealed that there are a number of subtly different methods of achieving similar ends. Variations in cleaving techniques used by traditional woodsmen cleaving fence stakes, rails, pales, gate bars, shingles and laths in England are considerable and are probably relevant even though none of those workers are trying to produce boards from really large logs. Some will start from the butt end of the log ' As you does yer old lady.' and others from the top. While some cleave against the flow of the sap (R. Champion Pers Com.). The comments in this study concerning cleft and hewn board production are thus based on first hand experience of the work tempered by a detailed knowledge of other experimental methods and results (Vadstrup 1997:89), and some ethnographic evidence.

6/11 THE PLANKS FOR THE SHEER STRAKES

Although wider than the rest of the hull planking at about 180-200mm wide, the tangentially faced sheer strake planks were cut from a smaller log(s) about 2.4m long with a diameter of only 0.30-35m. Such moderately straight, knotty logs could have derived from either the upper part of a medium sized woodland oak or the lower part of an oak growing in fairly open woodland perhaps of woodpasture type (fig. 58e). If these planks were produced by cleaving logs in half and hewing each half, considerable skill would have been required to obtain two usable planks. Experiments in the production of similar but thicker planks for Anglo-Saxon building timbers shows that they can be obtained from moderate quality oaks but require laborious hewing to remove irregularities and the curved outside of each half log (Append.4).

See-sawn sheer strake planks?

However, judging from finds of tangentially faced oak planking of this period in London and elsewhere it is more likely that the planking was sawn out of a small hewn saw-baulk. As far as we know from the study of saw mark patterns on land woodwork the method used around 1300 would have been that now termed 'see-sawing' (Goodburn 1991, 1992, and figs. 61c, 61d and Append. 4). The June 1999 findings of a clearly see sawn clinker ship plank of c. late 13th century date, at the London TYT98 site (Append. 6, fig.86, and Goodburn Forthcoming d,), indicates that the method was used for shipbuilding. If this method was used in Kentmere 1's case, half a medium-sized, rather knotty oak log could have been made to produce the four sheer strake planks, (fig. 58e). Historical sources for later medieval times (Salzman 1952:251) and recent traditional practice suggest use of a long ripping saw was a specialised craft practised by 'sawyers', as saws were expensive to make. If the sheer strakes were indeed sawn then it is likely that they were made from left-over planks from building work, given that it would have been costly to produce them from a saw baulk as many of the planks would not have been used. We would expect such oak plank to have been used for many building purposes at this period, such as floor boards, although most medieval sawn oak plank was cut from trees of greater diameter.

6/12 THE ASH PLANK ELEMENTS

The central thwart was made from a tangentially faced ash (*Fraxinus excelsior*) plank now 0.72m x 240mm x 25mm. Once again it is not possible to see whether it was sawn or cleft out (fig. 57f). It is probable that the plank 'orlokes' or oar pivots were made from planking from the same source.

The ash planks may have been left over from carpenters or possibly wheelwrights work, in which they were apparently used in medieval England (Clark 1984:20).

6/13 RAW MATERIALS FOR THE RIBS

It is not now possible to ascertain the original locations of individual rib timbers in the boat with certainty, due to considerable differential shrinkage, decay, and lack of labelling. However, the apparent 'best fit' locations are given in figure 62. The grown crook, single-piece ribs have been identified as birch (*Betula sp,* McGrail 1978:224) and more recently a fragment of one was microscopically identified as hazel (*Corylus avellana* , N. Nayling Pers Com.). It is taken here that the frames may be of both species. This mixing of species in framing timbers is known from the 10th century collection of timbers at New Fresh Wharf but is rare in English boatbuilding as a whole. However, it has been found in several Viking period finds in Denmark (Wagner 1986). Apparently the concern of the builders was to get more or less the correct naturally grown shape even if it meant using a rather rot-prone species rather than oak or another durable species such as yew.

The use of grown crooks was a widespread practice in pre-industrial boatbuilding for two reasons: firstly if the curved grain of a timber ran round the shape of a hull it would have the maximum strength; secondly much less labour and raw material was involved than in cutting parts of larger straight logs to a curved shape.

The use of rot prone species was less of a problem in small open boats than in large decked craft, due to the ease of, ventilation, inspection, treatment and replacement of frame timbers, while the use of wood tars and oils would have helped to slow down decay. The relatively slack fit of the ribs in this case would have allowed the bilge water to flow without the need for limber holes.

Finding the crooks

The Kentmere vessel's ribs are of a deep truncated 'V' form (fig. 62) and of a scantling which is rare in birch or hazel growing in dense woodland today. However, it can be found in the upper parts of moderately old birches growing in open settings (fig. 58c). Finding hazel of sufficient dimensions and the right spreading shape would be almost impossible today as it is most commonly found as coppiced underwood or in hedges and rarely reaches any size. However, it can very occasionally be found as a medium sized tree of spreading form and this growth habit may have been more common in the past than now. The ribs were hewn from two particular types of crook (fig. 58c). Ribs A and C appear to be main stem and branch crooks and B and D were 'Y' crotch crooks. It would probably have required the felling of at least two medium sized trees to obtain these shapes. Cutting the selected crooks without felling would have been very difficult, but not impossible with the tools of the period.

The scantlings of the surviving frame fragments are listed below: both the siding and moulding would perhaps have been c. 20% larger pre-shrinkage. They suggest that the builders might have aimed to make the siding of the ribs fairly regular at about 120mm or so (c.5"). No clear toolmarks survive.

Rib	max. sided mm	max. moulded mm
A	90	110
B	80	80
C	80	100
D	100	70

6/14 RAW MATERIALS FOR OTHER TIMBER ELEMENTS

The 'D' section stabilising beams are clearly not oak (cf. McGrail 1978:224). These have been identified microscopically as *Betula sp.*, birch (N. Nayling Pers Com.). The nearly complete shrunken starboard example is now 110 by 90mm and was cut from a slightly knotty whole log just under 3m long about 0.20m in diameter and 20 years old (fig. 58d). Such a log could be found towards the bottom of many modern birches. Clearly two such logs were needed for the boat.

6/15 WOODEN FASTENINGS

By the date of the re-investigation there were many modern fastening holes and some new wooden fastenings in parts of the vessel. These must have derived from attempts to reassemble the boat in the 1960's (fig. 54). Few fragments of the original fastenings survived. Thus, we are only able to glean a very general idea of what they were originally like from earlier recording work and the remaining holes.

1/ The ribs were fastened to the bottom of the hull with roughly made treenails with 25mm (1") square 50mm long heads (Wilson 1966:82). These were driven blind into the bottom of the hull. The remaining holes average about 22mm in diameter and vary between 25 and 40mm in depth. Two of these treenails were previously identified as oak (McGrail 1978:223).

2/ The ribs were also fastened to the top strakes of the boat with treenails (sp. and form not recorded). However, the surviving holes are 25-30mm diameter.

3/ The stabiliser logs were treenailed to the sides with four treenails each side. The surviving holes are 18-23mm in diameter.

4/ The oarlock planks were fastened with treenails, again the form of which was not recorded.

5/ There were also three through holes about 19mm diameter, roughly on the centre line of the bottom. They are still blocked with oak bungs and are interpreted here as thickness gauge holes.

These fastenings and bungs were probably made by the builders, from convenient off cuts.

6/16 METAL FASTENINGS, TRADED MATERIALS?

Despite the freshwater conditions in the lake bed, metal fastenings seem to have been too corroded to be recorded in detail on excavation and only faint stains and impressions survive. The lap fastenings were spaced at about 0.2m centres and the remaining holes are about 4mm in greatest dimension, and on the inside there are faint but clear impressions of roughly square roves here and there. Wilson records that '....round-headed, square shanked nails..' were used for lap fastenings (Wilson 1966:82). It has previously been suggested that round roves had been used (McGrail 1987:75), but there is not now any evidence to support that suggestion. Indeed they would have been very hard to make at that time, and without parallel. Thus, it would appear that the rove nails used as lap fastenings in this boat were similar to those used in most other medieval clinker boat finds found in England, although perhaps rather small. About 190-210 rove nails were used in the boat laps together with about 65 blind nails in the hoodends and thwart fastenings.

These iron fastenings must have been a significant expense at the time and were presumably bought at a coastal or riverine market. Presumably the rove nails were 'imported', as there could not have been a large enough demand in the immediate locale for this specialised ironware.

6/17 WATERPROOFING MATERIALS

No records appear to have survived of what the original seam waterproofing material was. Neither is it clear weather luting and or caulking were employed (see glossary, Append.1 for discussion of use of the two terms). However, some material must have been packed into the slightly irregular plank laps as they would have leaked badly otherwise. The evidence from other medieval boat finds from England suggests that this material would have been luting of either tarred moss or tarred animal hair (Goodburn 1991, Ryder 1996:200, and Append. 11). Both tarred moss and wool are being employed in the replica as luting.

6/18 SURFACE TREATMENTS

It is clear that some type of surface treatment must have been employed for the dugout hull and none durable elements (see 5/8). However, no records were made of any surviving traces; in practice degraded wood tar finishes are extremely difficult to distinguish on ancient waterlogged timbers and are often missed.

6/19 THE EXTRACTION AND GATHERING OF RAW MATERIALS, THE WORKFORCE REQUIRED AND SOME WIDER SOCIAL IMPLICATIONS

Timber for the dugout base

Little can be added to the general discussion of parent log handling described in chapter 5. The weight of the parent log for the dugout base of this vessel would have been about 1.25 tonnes (Appends.2,3). For the practical reasons discussed in chapter 5 it is very likely that the log for the boats base would have been roughed-out in situ. During the building of the replica it was possible for four adults to lever and wedge the partly shaped hull on to its side and then bottom (fig. 63). The green, 90% roughed-out, hull, weighing 0.25-0.30 tonnes was hauled out of the woods by four people using branches under the flat, smoothed and greased bottom (fig. 64). It is probable that a similar number of people or possibly, a draft animal would have been used for the original vessel. It is also probable that the builders would have chosen a tree growing close to water, where it would have been possible, with care, to float the roughed-out lower hull to a convenient building site. In upland Britain today large oaks are generally only found in sheltered spots which being low lying are often adjacent to water courses.

Timber for the planking

The parent log for the radially cleft boards would probably, have been cleft into manageable sections before transport as unconverted it would have weighed 0.3-0.4 tonnes. By contrast the cleft sections for the boards would have weighed less than 10kg each. Indeed, it may be the case that the boards were roughly finished where the tree was felled, the infra-structure required for this being very limited. In practice, one fit adult can carry two or three green, cleft boards of the size required for this vessel, several hundred yards with ease, the use of a cart or boat would have allowed one adult to move all the boards to the building site in one trip. Practical experience also shows that it would have been quite possible for one individual working alone to have produced all the cleft boards. However, for social and psychological reasons, it is suggested that a pair of workers may have worked together. The making of such relatively short, narrow, clove board would have required only moderate skill.

The tangentially faced, sheer strake planking, would most likely have been converted close to where the parent tree was felled, however it was converted. The parent log would have weighed approximately 0.15 tonnes. If a squared saw baulk had been prepared it would have weighed about 0.10 tonnes. Lifting up one end of the saw baulk at a time, as required for see-sawing, would have been possible for one strong adult. Each rough plank would have weighed about 10kg when green.

The selection of the 'V' shaped rib timbers would have required a keen sense of, and memory for, shapes and scantlings. In practice, the most convenient way of carrying such 'crooks' is slipped over one shoulder. Any fit adult could have carried one some distance, after it had been bucked and perhaps slightly trimmed with an axe.

6/20 THE EXTRACTION AND GATHERING OF TARS, FATS AND WATERPROOFING MATERIALS

As no clear evidence of surface treatment or paying and luting was recorded this area is speculative. If the Kentmere builders relied on animal fat as a waterproofer and timber treatment, then the production would have been a relatively simple domestic matter of rendering down fatty meat and bones, whilst if wood tars and/or resins were used they would have to be bought-in. The nearest substantial stands of native pine trees would have grown at least 150 miles to the NE in the Scottish highlands. It is probably just as likely that pine tar would come to the coast, a few miles to the south from distant parts such as the Baltic at this period. If it was used in the Kentmere 1 boat it would come in from merchants based there.

6/21 EVIDENCE FOR SECONDARY WORKING, TRIMMING TIMBERS AND ASSEMBLY OF THE BOAT

Toolmarks and toolkits

The systematic recording of toolmarks was not part of accepted practice during the excavation of timber structures in the 1950's and no such records appear to have been made. The post-depositional decay, excavation, use wear, cleaning, reburial and surface consolidation work have obscured or destroyed most toolmarks. However, a few marks still survive on the boats lower hull in protected positions (listed below).

1/ An axe stop mark top edge lower hull, for'ad port side (fig. 65a).

2/ Chisel marks under lead patch inside stern (fig. 65b).

3/ Several sizes of auger holes.

Additionally, it is clear from the slightly undulating surfaces on much of the lower hull and some of the radially cleft planking that these elements were trimmed by hewing, most likely with a broad bladed axe of some type. Clear evidence for the use of a broad axe with a fairly straight blade well over 170mm wide was recorded on the plumb sides of the 13th century Wasdale Beck dugout boat found in the same region (Goodburn Un Pub 1990).

Known tool kit used on the Kentmere 1 boat.

The evidence noted above clearly indicates that the original builders used the following tools;

1/ A moderately thin bladed axe with a slightly curving blade over 80mm in width (fig. 65a).

2/ A pair of augers, one of approximately 20mm dia. and another of about 25mm dia.

3/ A square ended chisel with a blade 22mm wide (fig. 65b).

4/ The stepped nature of the marks indicates that the chisel was driven with a mallet rather than pushed.

5/ A moderately light hammer, probably with a chisel peen for nail driving, cutting and rivetting (see Append.9).

Implied tool kit

Using the experience gained from work on the replica, knowledge of medieval carpentry practice and the ethnography of dugout boatbuilding, it is possible to suggest that the following known types of medieval tools would probably also have been used;

1/ A heavy, fairly narrow bladed felling axe, for bucking and roughing-out.

2/ An adze of some type to trim and smooth the lower parts of the bottom inside, as an axe could not be wielded in such a confined position. Such a tool may also have been used in trimming and smoothing other parts of the lower hull.

3/ A large hammer or iron 'dolly' to hold up against the nail heads outboard during the rivetting up of the rove nails. (it is also possible that the back of a heavy axe could be used for this job)

4/ A hardwood or iron 'rove set', a tubular drift used to force the rove on to the nail shank (fig. 61a).

5/ Simple wooden clamps ('nippers') to hold the clinker planking in place during building (fig. 61b).

6/ A large 2 man rip saw for cutting the probably sawn planking (fig. 61c)

7/ A large, heavy trestle for the use of the above (fig. 61c).

8/ A snap line for marking out the saw baulk for cutting the probably sawn oak and ash planking.

9/ A pigment, such as soft charcoal, for the above and other marking.

10/ Dividers and/or a rule for marking out the saw baulk.

11/ Pole levers for rolling the log during building.

12/ Rope for hauling the boat to a launch site, etc.

13/ Possibly a cart , sledge, barrow or boat to move some of the raw materials.

14/ Possibly a drawknife or shave of some type for smoothing plank laps and edges.

15/ A rag or brush for applying surface treatments.

16/ Logs or trestles to support the boat during the later stages of work.

17/ Possibly wattle hurdles or similar screens to keep off potentially damaging sun and wind.

18/ Plumb bob for marking out the timbers and possibly in the hanging of the strakes?

The comparatively large array of tools needed to build this vessel can be contrasted with the much smaller tool kit required to build the Clapton boat (5/6).

Bending the hood ends

The hood ends of many of the boards retain a strong bend which accommodated the sharp curve round the lower hull end-blocks, particularly the stern. No clear evidence of how this was achieved has survived. The hood ends of some 19th century N. Atlantic small boats were hewn out with a twist (Gothche 1985:33). It is possible that this was done for the Kentmere boat. However, as the grain direction in the hood ends more or less follows the shape of the plank the following are perhaps more likely; the boards were deliberately cleft out of a log with a twist in the grain at one end, or that the hood ends were rendered pliable and bent. Several methods are known for rendering more or less straight planks or boards pliable for acute bending in European boatbuilding. Evidence for the use of particular methods in medieval England is discussed in detail in chapter 7/6/9. This area is currently undergoing practical research during the replica building project.

Labour input during the assembly and finishing work

It is obviously extremely difficult to be precise here, though a few generalisations based on the experience gained through the replica project and other experimental work are perhaps useful. Two or three people could actually work on trimming and finishing the hull. In recent dugout boatbuilding world-wide the most skilled worker tends to finish the vessel on his own or with the help of one other worker (McGrail 1987:35, Roberts and Shackleton 1983:104 etc). This practice has been followed in the building of the replica.

6/22 REPAIRS AND LIFE HISTORY

The short end grain of the bow and stern of the oak hull was clearly weak and very prone to splitting. This has been noted as a considerable problem in the replica. The original vessel clearly suffered severe end-shakes such that it would have leaked badly without repair. On the inside of the stern an irregularly shaped sheet lead tingle was nailed over the split to prevent excessive leakage (fig. 66a). The iron nails used had square shanks 4-5mm across and round heads 15mm in diameter but had largely corroded away. As constructional chisel marks were very well preserved under this tingle, but not elsewhere, it would appear that the repair was carried out fairly soon after building.

The wear evident on the inside of the Kentmere 1 hull is suggestive of a period of use in excess of 3 years. The apparent lack of ancient decay in the rot-prone ash plank fittings and slight traces of oak sapwood implies, either careful maintenance or perhaps more likely a relatively short life of less than 10 years before abandonment.

The smoothness of the bottom is probably due to the abrasion caused by grounding and hauling out on the lake shore. Experience shows that such smoothing can happen quite rapidly, within one year of use.

6/23 KENTMERE EXTENDED DUGOUT AS A SKEUMORPH?

Rather than seeing this vessel as the product of the expedient repair of a simple dugout it could be considered as a laborious, deliberate attempt to copy the form of a flat-bottomed, hard chined, plank built vessel. Medieval vessels with hard-chined flat bottomed hulls are known from N.W. Europe outside Britain such as the Falsterbo find from Sweden (fig. 66b). The rather angular form of the 13th century Wasdale Beck boat found relatively close by might also be taken as following planked boat precedents (fig. 45b).

Examples of dugout vessels being wrought to a shape echoing plank built craft have been documented from at least the early Iron Age in Britain. Indeed, the practice of copying features of planked vessel construction in a dugout medium can still sometimes be seen in craft from the Caribbean (Leshikar 1975) and elsewhere.

6/24 SUMMARY

It has been shown that a much greater range of skills, tools and raw materials were employed in the building of this craft than those required for a basic dugout. The level of particular skill required to build the vessel might imply the involvement of one or more people experienced in such work assisted by others. However, it is probable that in this relatively isolated rural comunity any such specialist was not a full time boatbuilder, but someone who carried out varied types of woodwork.

It is clear that the owners of the craft had sufficient surplus wealth and/or power to enable the collection of the diverse natural and manufactured products for the building of this complex extended dugout. Some evidence of the trading networks necessary for the building of such vessels, for the provision of nails for example, has been demonstrated. These factors can be taken to illustrate the extent to which the craft was integrated into the life and work of the local extent to which the craft was integrated into the life and work of the local community. The new graphic reconstruction proposed here would have had greater utility in terms of burthen and stability than previous graphic reconstructions. However, the considerable increase in performance over that of a simple dugout boat required the consumption of greater quantities and varieties of materials and labour. These factors must have their echos in the social, cultural, environmental and economic circumstances of use of the craft, points developed further in chapter 9.

Finally, detailed investigation of the raw materials used has enabled elements of the extinct local landscape to be reconstructed; including the specific forms and species of trees used and their likely growing environments.

6/25 FUTURE WORK.

Tree-ring analysis

Several aspects of this important small boat are worthy of further investigation. The most pressing a is a tree-ring study of the surviving timbers, which might throw light on the following aspects; the building date, the provenance of the materials, and possible same-tree origins for some of the timber (Append. 7). However, the condition of the timbers and relatively short ring sequences might prevent successful correlation's being made.

Completing the replica

In order to understand more fully the later stages in the building process such as the fitting of the ribs and thwarts it is essential to finish the replica. This would also provide opportunities for the collection of performance data.

The local historical context

If this vessel is to be more securely placed in its social and economic background archaeological work on the nature of contemporary settlements in the area would have to be carried out.

7/ SELECTED ASPECTS OF THE PRACTICE OF BUILDING PLANKED VESSELS C.900 TO C.1600 AD

7/1/1 INTRODUCTION, AND TERMS OF REFERENCE FOR THIS CHAPTER

A justification for studying fragmentary nautical finds and the organisation and limitations of this section of the study

Few well preserved, relatively complete, plank-built vessels (wrecks, abandoned hulks, or burial ships) have been found in England or English waters dating from c.900 to c. 1600 AD. Many technological features of these few finds have not been recorded in detail. Several key finds currently await detailed publication such as the Mary Rose. A notable exception here is the 10-11th century Graveney boat, found in a silted creek of a tributary of the lower Thames estuary in 1970 (Fenwick ed. 1978). In this case a considerable amount of technological detail was recorded, some of which we can now reinterpret in the light of more recent work (7/4/1, 7/5/2). Another project of note, slightly less fully, but more rapidly published, is the Magor Pill vessel of the 13th century found in the Severn estuary near the English -Welsh border in 1994 (Nayling et al. 1998, here Append.6 for note on a probable English origin for this vessel).

Finds made in the 1970's and 80's such as St Peter Port 1 and 2 and Buss Creek vessels (Hutchinson 1994a:196-7), have not been investigated thoroughly or published in detail. However, in some cases detailed re-investigations are now in hand (1999, G.Milne re-The Sandwich ship, Pers Com. and J. Adams re-the medieval Peters Port vessels Pers Com.). However, a huge number of more fragmentary finds have been made, varying from small isolated pieces of boat planking to large articulated sections of clinker planking over 15m long, or almost complete keels. Thus, the limited record of few relatively complete vessels can be extensively supplemented by study of the fragmentary material, of similar type and date. It is also often the case that the fragmentary finds have been recorded in more detail (eg. Hutchinson 1984, Goodburn 1988, 1990, 1991a, 1994, 1997a,). Usefully some large collections of fragmentary material from earlier work in London and other parts of NW and N Europe have been published during the course of this part-time study. These now provide essential comparative evidence that at the beginning of the study only the Bryggen report could provide (Christensen 1985, McGrail 1993, Marsden 1994, 1996, Crumlin-Pedersen 1997).

Most of the fragmentary material excavated in England has been found reused in waterfront structures, most prolifically in London (Chapts.2 and 4 and Append.6). The material dates from the 8th century to late in the post-medieval period. Remains of both clinker, carvel and composite planked cog type craft are exemplified. The sizes of 'parent' vessels represented ranges from lightly-built small craft (probably less than 10m long) to large heavily built seagoing craft over 30m in length (Append.6).

The following text is largely presented in comparative terms with material being described in structural groups subdivided chronologically, where appropriate. A number of important issues are not considered in detail here due mainly to limitations in the evidence these include; the making and fitting of framing elements, the making and fitting of fastenings and waterproofing measures, surface treatments, deck structures, rigging and the life history, repair and use of vessels. However, some significant new evidence or insights in some of these areas have been made during this study which are briefly summarised in the appendices 9-12 and will be covered in future work.

From the keel up and the most numerous evidence, various forms of planking

The text has also been arranged in the approximate order of building for most medieval planked vessels starting with the fashioning of bottom of the craft followed by the ends, and then the planking (clearly in a few of the latest carvel built parent vessels the planking would have followed framing). The approach also concentrates on the most numerous categories of vessel parts found to date, such as hull planking and keels. Elements that have rarely been recorded in England, such as, stringers, burthen boards or mast steps are deliberately excluded, as are fittings, such as oars and rudders for reasons of space and their comparative rarity. However, a brief listing of some recently found elements in the excluded categories is noted in Appendix 6, and some comments on framing procedures are made below where appropriate.

7/1/2 SOME KEY AREAS DEALT WITH BY OTHERS IN RECENT YEARS

The order of assembly question; shell or skeleton first?

The order of assembly of planked hulls in medieval NW Europe, over this period, is now fairly well known, all types having been shell-first built except in some forms of carvel building where framing was erected first from the late 15th century. The evidence for the use of the shell-building sequence is overwhelming for all vessels built in; the clinker 'keel' style (eg.Fenwick ed. 1978:221, Hutchinson 1994a:36, Crumlin-Pedersen 1997:23,) the 'hulc' style (Vlek 1987:105, the 'cog' style (Van de Moortel 1991:43,) the flat-bottomed 'praam' (or barge) style (Crumlin-Pedersen 1997:300) and even in some carvel built craft (Maarleveld 1994:159). However, some of the earliest English built carvel ship evidence appears to indicate some form of skeleton-first system (Dobbs re-Mary Rose Pers.Com.). Thus, the use of a shell-first building system is assumed where relevant below.

The forming of hull shape

In most forms of traditional clinker boatbuilding the angle of joining and width of the strakes at several points along the hull of a vessel together with the form of the ends are the features used by the builders to govern hull shape (and strake shape). These aspects of forming the shape of clinker hulls in relation to medieval practice have been extensively covered by AE Christensen principally from a 'living tradition' perspective (Christensen 1972). Thus, this area will not be explored in detail here. However, the characteristic shapes of strakes from particular zones of the hull of keel type vessels will be referred to where relevant.

The problematic reconstruction of the size of parent vessels from fragmentary finds

Systematic attempts have been made to allocate reused nautical timbers to closely defined size categories of parent vessel (McGrail 1993:19), but Crumlin-Pedersen has recently shown this to be very unreliable in practice (Crumlin-Pedersen 1997:106). It is not therefore, attempted here except in the broadest and most general sense, such as, these elements derive from a large ship or conversely from a small boat. One problem fundamental to this period and SE England in particular is that many traditions of building are represented from c900 to 1600, each with clearly different combinations of proportions of one feature against another (Goodburn 1994a).

7/1/3 KEY AREAS ADDRESSED BELOW

Reconstructing toolkits and craft practice

Following the precedent set in the previous two chapters, planked craft are seen explicitly as structures set within particular economic, socio-cultural and technological spheres (Chapt.3). Thus, information bearing on the tools used, workshop organisation, logistics and labour input will be highlighted, although most of the more synthetic comments and analysis will be reserved for Chapter 9.

Reconstructing parent logs, parent trees, treescapes and aspects of woodmanship

Vessels were not built on the sea or rivers, nor of materials from them in medieval northern Europe, although maritime resources such as driftlogs were used for medieval boatbuilding in exceptional cases in some remote N. Atlantic settlements . Thus, as complex collections of carefully harvested land produce such as, timber, wood, iron and wool etc., vessels have the potential to inform us about contemporaneous cultural landscapes, how they were managed and how this changed through time. From pilot studies of land-based woodwork of our period it has become quite clear in the last few years that there were indeed far reaching changes in the nature of the exploited English landscape during our period with the extinction of wildwood-type conditions by about 1250 AD (Rackham 1976, 1980, Goodburn 1992a, 1994b, 1998). One of the key questions for historical ecologists of this period then is 'What were the trees of the last of the wildwood type forests of England actually like'? Information provided below provides some insights into this murky field adding to that gleaned from studies of land based evidence (Chapt.9).

A few nautical archaeologists have recognised the potential of studying timber finds for reconstructing extinct trees (McGrail 1978:243, 1987:35, Crumlin-Pedersen 1986a:220, Rival 1991). However, the methodology for so doing has not generally been explicit, nor has the issue of the affects of woodmanship practices, or contemporaneous often more voluminous evidence from non-nautical structures been considered in any depth (But see 3/2/4 for a more detailed consideration of this issue). A summary attempt at comparing and merging the pictures derived from nautical and non-nautical material is included in chapter 9. Here the practical imperative of serious replica building has been essential to give a solid grounding to some of the hypotheses developed (Crumlin-Pedersen 1986a:220, 1997:179, Goodburn 1992b,1993c:200).

A systematic, explicit, illustrated approach

The systematic process by which first, 'parent-logs', then 'parent trees' and finally hypothetical 'treescapes' and woodmanship practices can be reconstructed is described in detail in Appendix 2 (Goodburn 1991b, 1992a). The principal focus here is the reconstruction of the logs used for planked vessels and the trees from which they were cut. Clearly the question of where the timber was felled is crucial, as larger vessels can move long distances and may sometimes enter the archaeological record far from where they were built (Crumlin-Pedersen 1990). Also documents show that timber was being traded to England as early as the

13th century explicitly for shipbuilding (Hutchinson 1994a:150, also see entry in Append. 6 for TYT98 for possible archaeological evidence of the trade). However, tree-ring studies have shown that the vast majority of the finds examined for this study were built out of timber grown in SE England (eg. Tyers 1994a, 1994b Append. 7). Therefore inferences about landscape change drawn from the remains can often be located to a region if not a precise locality. Occasionally nautical timbers of clearly foreign origin have been found and the parent trees were features of foreign landscapes (Goodburn 1994a103, Tyers 1996a:196).

For each category of hull element described below at least one hypothetical parent tree reconstruction drawing is included. A problem of note here is the difficulty or impossibility of distinguishing ancient timber of the two native species of oak (*Quercus robur, Q. petrea*) or their hybrids (Wagner 1986:132, Frost 1985:2). However, both species are very similar and often form mixed stands and hybridise in the SE of England so that it is legitimate to consider them as 'oak' for our purposes.

7/2 ASPECTS OF BUILDING FLAT BOTTOMED CRAFT

Britain has remarkably few flat bottomed vessel finds dating to before the early 19th century although judging from continental parallels hard-chined medieval vessels ought to have been common on large rivers and meres. Hopefully elements of such craft will be found (see below) as continental evidence shows that they often required special timbers and building methods not used in round hulled construction (Crumlin-Pedersen 1997:300, Hakelberg 1996).

For example analysis and recent experimental work has shown that the bottom of the wide, punt-shaped, 12th century Egernsund barge, from Southern Denmark required the production of particularly wide and flat cleft oak boards (Finderup 1996). In the later medieval to 16th century Caldecote boat from England, a wide sawn elm (*Ulmus sp.*) plank was used (Hutchinson 1994a:126).

Very recently a reused section of the bottom of an up river, flat bottomed punt-shaped barge was found on and excavation in Southwark at site MFB98. This material is currently undergoing study and will be dealt with in future work (Append.6).

7/3 DUGOUT BOTTOMS FOR PLANKED CRAFT AND PROTO HULK BUILDING

The use of a dugout lower hull for small craft has been dealt with in chapter. 6. so here the focus is a brief description of the construction of dugout bottoms for larger planked craft sometimes termed 'proto' or early 'hulcs'. (Ellmers 1972:59, de Weerd et al 1987, Goodburn 2000a, and figs.68,69b.). These unusual craft were firmly associated with Frisian seafearers and their trading to and from England, but there is still much debate about their form and construction. However, work recently underway on a re-examination of the remains of the large Utrecht ship have clearly shown that it did indeed have an expanded dugout bottom (Van de Moortel Pers Com.).

7/3/1 EVIDENCE FOR MAKING THE BOTTOMS OF EARLY HULCS

The debate on the expansion of oak dugouts

Some authors have contended that it is very unlikely that oak dugouts could have been expanded in the manner sometimes used with other species (McGrail 1978:41, and fig.67). Others suggest that it was a technique that was quite widely used in early medieval times throughout NW Europe (Crumlin-Pedersen 1990). Recently the technical possibilities of expanding hewn sections of oak were subject to limited testing and the principle shown to be feasible (Gifford 1993). However, it is still an area that requires full scale experimental investigation. During the reediting of this study the first experiment of this kind took place in Switzerland when a small oak expended dugout was built copying one of the early medieval Slusegard sand impressions (Crumlin-Pedersen 2001). It will be extremely interesting to read more of this experiment in the future.

The ethnography of boatbuilding provides a number of examples of the use of expansion (eg. Leshikar 1975 for a clear account). The essence of the expansion process is; producing a very finely hewn, thin dugout hull, which is then rendered pliable by soaking and heating, and gently made wider, the ends of the vessel also lift up and it assumes a more 'boat-shaped' appearance . Expansion produces a wider more stable and seaworthy vessel than could be hewn from one unexpanded log (fig.67).

The Netherlands finds

Utrecht 1 has the classic shape of shallow 'U' amidships and up swept ends which are partly an artefact of the expansion process, although Vlek denies the possibility (Vlek 1987:107, fig.14). A similar approach was clearly used in the case of the much smaller, broadly contemporary Velsen boat as recognised by de Weerd (1987:266) and in the slightly smaller Water Straat boat (Vlek 1987:89).

The first evidence from England

Two fragments of what appears to have been the dugout base of a vessel built in this Low Countries or 'Frisian' style were found at Bull Wharf (BUF90, [8075]) in 1995, Ayre et al In Prep). Coincidently the site forms the eastern side of the Queenhithe dock inlet, which was apparently visited by craft called 'hulcus' in the early eleventh century (Lebecq 1990:89). The largest fragment was intact enough to have some concavity. It also had a smoothly bevelled lap and line of fastenings for the first added strakes together with broken iron sintels (fig. 68). Planking of what must have been the same Frisian hulc are dealt with below (Goodburn 1994:103, 1997:32, and 2002a). Traces of charring were found on the outboard surfaces of the timber, none of the other timbers from the vessel were burnt. Thus, it is possible that this is evidence of the use of fire to expand the dugout base.

A few axe or adze stop marks survived on the outboard face. The direction of use of the tool suggests that they were probably the marks left by an adze with a blade over 60mm wide used for trimming the outside of the dugout base, whilst it was upside down. If the precedent of the other hulc type finds from the Low Countries can be used, then the fragment probably derives from towards the stern end. In the case of the Utrecht 1, and Water Straat boats the smaller top of the parent tree was used aft (Vlek 1987:75). The knottyness of the larger Bull wharf fragment suggests an origin well up in the parent oak. A whole log was used in the Low Countries finds.

A highly hypothetical reconstruction of the parent vessels possible cross section is shown in Figure 69b. Tree ring study of the associated planking (see below) reused in the same early eleventh century structure shows that the parent vessel was built between about 960 and 980AD and that the timber was probably of Low Countries origin (Tyers 1994a).

Possible secondary evidence of the use of a small expanded dugout

A strongly curved small boat frame was found abandoned on the Thames Exchange site (TEX88 [2411]) in an eleventh century context. Its general lack of fastenings or notches ('joggles') for overlapping clinker planking suggests it may have come from a small expanded dugout vessel. This vessel may have resembled the Stanley Ferry boat from Yorkshire which is believed to be of the 10th century AD and shows signs of having been expanded. It also had two unjoggled ribs in position when found (McGrail 1978:275).

7/4 EVIDENCE FOR THE MAKING OF KEEL MEMBERS FOR ROUND HULLED PLANK BUILT CRAFT

These elements were often hewn to complex varying shapes during medieval and early post-medieval times and formed the foundation or backbone from which craft were built up (figs. 70,71).

7/4/1 PRE-CONQUEST APPROACHES TO KEEL MAKING

The Graveney example

The oak keel of the Graveney boat of c.10th century, is of broad plank-like form with a shallow projection along the underside, and it tapers markedly from midships toward the bow and stern (McKee 1978:94). The shape contrasts with broadly contemporary keels from Scandinavia and Hiberno-Norse Dublin which were more of a 'beam on edge' in shape (figs.9,70).

The reconstructed parent log and evidence for making the keel

The full length of the keel was not found , but by assuming symmetry about a widest mid point a length of about 7m is suggested by 440mm wide, and a worn depth approaching 90mm amidships (McKee 1978:94, fig.70a).

It is clear that it was hewn from a log cleft in half and it was suggested that the parent log would have been 0.7m in diameter (McKee 1978:94). As the keel was only 440mm wide and had a little wane surviving here and there the figure of 0.7m is probably a slight over estimation. Allowing for the removal of bark and sapwood totalling about 150mm the diameter at chest height would have been in the region 0.6m and the tree must have been straight with relatively few side branches. We have no information as to its speed of growth, or the orientation of the butt within the finished vessel.

The garboard fastenings were small , rawl plugged, iron rove nails (Append.9), and the scarf with the after stem short, edge-halved, fastened with similar nails (fig.70b).

The recently found pre-Conquest London keel finds

Parts of four keels dating to before 1100 AD have been found and are briefly described below (fig.70c-f). All these keels were more mutilated by original wear, reuse or mechanical excavators than the Graveney example but many addtional technical details have been recorded. None of the first three timbers could be tree-ring dated due to a lack of rings but the contexts of reuse were reasonably closely dated by tree-ring and finds dating.

The tenth century Thames Exchange keel (TEX88 [2413])

This keel was excavated in several sections partly by hand, partly by machine, during the last days of a highly pressured rescue excavation. The drawings piece together the best preserved sections only. The keel was reused in a low stake and plank river wall of the late tenth to early eleventh centuries (Milne and Goodburn 1990:633). As the keel was old and worn it is likely that the parent vessel was built around the middle of the tenth century or a little later.

When first exposed parts of a scarfed garboard were still attached indicating that the narrow end was probably the stern (fig.70c.). Some of the fragments were too battered to fit exactly but some idea of the overall length of the original keel was gained. In total the reused keel was at least 5.3m, about the same length as that found intact in the Graveney vessel. The taper towards the bow was well underway, assuming symmetry about a centre point and enough additional length to form joints with the stem and stern posts, the original keel must have been at least 7m long or possible a little more. The flanges at the sides of the keel were somewhat damaged but the maximum width must have originally been about 0.335m, with a minimum depth of about 105mm deepening in the slightly rising stern section.

The timber had been hewn from half a cleft log. Unfortunately no clear toolmarks survived from the original shaping of the keel. This keel and all the others noted here, would have been shaped with the use of a line to guide straightness. The fastenings were small Graveney style, rawl-plugged, iron rove nails (Append.9) and the luting tarred hair. It had two other features resembling those of the Graveney vessel. An oak through treenail or plug of 25mm was found towards the stern and a small 'V' shaped cut in the upper face on one side at the stern end. The treenail was probably a relict of the building process used to locate the keel on the stocks. The 'V' shaped cut may have been an aborted attempt to cut the riveting grooves found in the Graveney stern post. Although similar to the Graveney boat keel the TEX88 example was proportionately a little narrower and deeper. It is assumed here that the keel belonged to a small coasting vessel, the eroded hole in the stern end of the keel may perhaps have been used to haul the vessel out of the water periodically for repairs or winter storage (J. Bill Pers Com.).

Reconstructing the parent tree and logistics

It is clear from the slope and position of the knots that the butt of the parent oak was used towards the bow. This may have been due to the need to use the strongest timber where it might be most likely to suffer impact damage. The timber of most oaks is tougher and more split resistant at its base than anywhere else except where very knotty. It might also be that more timber was required for a slightly deeper or more rising keel towards the bow. It was possible to count about 50 annual heartwood rings in the timber, allowing some for the sapwood, the tree would have been around 75 years old. Thus, the tree was moderately fast grown, fairly straight with little taper. It would have been about 0.55m in diameter at chest height. Oaks with these characteristics can be found in fairly dense coppice with standards type oak woodland in the London area today (eg. Barnet wood, Bromley) and also in established areas of woodland without coppice growing up on old agricultural or pasture land.

The halved, bucked and lopped, parent log would have weighed just under half a tonne (using the standard weight approximations for green oak, Append. 3), whilst the roughed out keel would have weighed around 1/5th of a tonne. Therefore it seems likely that the keel would have been roughed-out where the parent tree was felled, before transport.

Notes on asymmetry and dead rise

Attempts have been made to accurately reconstruct the degree to which the bottom of parent vessels rose (the 'deadrise') based on the angle of the parts of the keel where the garboards were attached (McGrail 1993:12). However, most keels from early medieval boat finds from NW Europe, including the London finds, are rather surprisingly asymmetrical to modern eyes, so dead-rise angles deduced would often vary markedly from side to side. That said the overall shape of the TEX 88 keel seems to fit an origin in a fairly flat-floored vessel.

We can deduce from the above generalisation that what actually mattered was the angle and height of the outer top corner of the garboards once fitted rather than the absolute symmetry of the keel rabbets.

The larger keel from Vintners Place (VRY89 [5656]), of the late tenth to early eleventh centuries

This keel was reused in a similar manner to that from TEX88 less than 100m to the east and excavated in several fragments which could just about be refitted. Unfortunately the timber had decayed and was more mutilated than the TEX88 example. In form it was proportionately narrower and deeper still and may have derived from a narrower, longer vessel as it was over 4.37m length from somewhere near midships towards one end and must have been well over 8m long originally. The maximum original width must have been around 280mm with a depth of about 105mm (fig.70e).

Again the keel was hewn from a halved oak. The parent oak was of medium to fast growth about 75 years old and rather straight. In this case it is clear that the narrower end must have been very close to the usable length as the width of the heartwood and degree of knottyness implies.

The smaller keel from Vintners Place (VRY89 [5714])

This oak keel timber dates to the early C11th and was reused as a pile (fig.70f). Although only 1.86m long as recorded it was important for the information it provides for how the keel-stem joints could be made (fore or aft). It was an edge-halved scarf and the fastenings were a combination of at least four oak-wedged (willow?) treenails and the tapered end of the stem was fastened with rawl-plugged, Graveney style nails, it is not clear wether they would have had roves but this seems likely for strength.

The keel differed a little in form from the others and with a maximum original width of approximately 200mm and depth of 90mm it is rather narrower and deeper. There was also a clear rabbet hewn into the very end. The bulk of the fastenings were of the Graveney type, where as in the rabbet they were simple blind nails. The keel was less worn and decayed than the others and clearly showed the axe marks of the ship breaker. Two scribed lines presumably marking the position of the end of the stem, which was apparently adjusted, also survived.

It is not clear what type of vessel it derived from although it may be that the hull form was leaner and deeper than the Graveney example. It is also clear that the keel was laboriously hewn from a whole log as was done for Viking period vessels in Scandinavia (Nielsen 2001). About 65 annual rings were counted and no trace of sapwood found thus, the parent tree was probably at the very least 80 years old and slower grown that those used for the other keels.

The late eleventh century Fennings Wharf keel (FW84)

A 2.5m length of broad oak plank-keel was found during a watching brief at Fennings Wharf, Southwark. The keel was about 365mm wide with a maximum depth of 96 mm (Marsden 1994:156, fig. 70g). A fragment of garboard was attached with a preserved scarf showing that the keel tapered towards the stern. The fragment of garboard was dated indicating a date in the later 11th century for the keel. It was suggested that the flat top and bottom of the keel were sawn (Marsden 1994:156). This would be exceptionally early evidence if that were true. However, on first hand examination of the keel by this writer no traces of saw marks were seen. The surfaces were worn but had the slightly undulating finish commensurate with hewing a timber from half a cleft log. The shape and multiplicity of knots shows that the butt of the tree was also used towards the bow in this case.

The garboard fastenings were unusually iron nails that had been turned inboard, rather than fitted with rove nails. The tree-ring work showed that the timber was relatively local and hence the apparently foreign technique well known later in the Low Countries (Ellmers 1985:60) was employed in SE England for this vessel (Tyers 1994a:208).

Are these early medieval keels distinctive within the broad church of clinker boat and ship building in NW Europe?

They are clearly shallower and more plank-like in form than the vast majority of finds from the southern Baltic and Scandinavia. However, the smaller keel from VRY89 is rather similar to the 10th century keel T361 from Hiberno-Norse Dublin (McGrail 1993:148) and approaches the proportions of some of the Scandinavian finds. The lack of information from any other region of England apart from the Thames estuary at this period is a substantial problem here.

The lack of evidence for use of the 'lot' ('underlout') and vertical scarfs

The use of the 'lot', a curved intermediary timber between the keel and stem is a well known characteristic of Scandinavian medieval boat and ship building (fig.72). The lack of evidence for its use in the limited sample of late Anglo-Saxon work from SE England suggests that it may have been rare in Pre-Conquest England, but more material is clearly required to clarify the situation.

7/4/2 POST-CONQUEST MEDIEVAL KEELS AND THEIR MAKING

Unfortunately even less evidence is available for the Post-Conquest period. The principal examples are also clearly river or estuarine vessels and may not be typical of larger sea-going vessels. The quality of the technical detail of the record is also lower, but still worth brief examination.

The keel of the Blackfriars 3 boat

This vessel was excavated in extremely difficult rescue conditions and much detailed recording was not initially possible (Marsden 1979) . However, parts of the hull were lifted and much later subjected to more detailed examination by Marsden and Caldwell, this description is based on that work (Marsden 1996:62). The tree-ring work shows that the boat was built around 1400AD of oak from SE England (Tyers 1996a:198). It was clinker built just over 14m long and of a flat-floored, keel type, for river and possibly estuary use, what was then termed a 'showt' or 'shoute' (Spencer 1996).

The keel member was of oak 10.77m long in two lengths joined apparently, by some form of stop-splayed scarf about 340mm long fastened with six rove nails (Marsden 1996:62). The longest element was 8.42m, with a width of 430mm and depth of 140mm. Overall it had a similar tapering shape to the earlier keels and was of plank form. However, the cross section was complex with a deepened central section (fig.71a).

It was clear that it had been cut from half a log but not how that was done. The fastenings to the garboards were substantial iron, square-shanked rove nails, without rawl plugs, with roves of rectangular or diamond shape (Append.9) . The luting was of tarred goat hair (Ryder 1996:206). The scarfs with the stem and stern posts where short and stopped-splayed secured with rove nails. At the stern post there was an intermediary timber when found between the upper element and the aft end of the keel. The top of the intermediary was simply bevelled off to form a short splayed scarf, secured with iron nails, the inboard edge of the scarf was covered by a small patch. It appears that the upper timber may have been a repair and the lower not originally an underlout.

Magor Pill, a glimpse of a quite different keel form

This vessel was excavated and lifted in 1995 just over the border in SE Wales and was briefly visited in situ by this writer (Redknap and Nayling 1997, Nayling et al 1998). The hull was clinker built and appears to have been a small coaster of keel type. The tree-ring study shows that she was built in 1240AD, principally of oak with very close matches to Gloucestershire chronologies (Nayling 1998:121, and Append.6). The keel form provides a useful contrast to those from London in that it was hewn from a whole oak and was of beam form with deep rebates. This note serves to demonstrate how more evidence will undoubtedly broaden and deepen our view of regional variation in planked boatbuilding in medieval Britain.

Interestingly the parent tree for the keel was graphically reconstructed (Nayling et al 1998:48) but seems to have been drawn rather larger in diameter and more tapering than the recorded evidence suggests.

7/4/3 EARLY POST-MEDIEVAL KEELS AND THEIR MAKING

The keels of early sixteenth century carvel-built vessels in brief

Few of these have been found and reported on in any detail but the following summary notes are relevant for contrast with the medieval evidence. The Cattewater wreck's keel was only examined in situ on the sea bed over a relatively short length (Redknap 1984:21). However, it was found to be oak about 300mm wide and probably of the same depth. It was deeply rabbeted in the sides for the garboards. The Studland bay wreck's keel was only found as part of the dislocated aft keel assembly but was clearly of oak (Hutchinson 1991:171). A key problem with these two finds is that they may both be of Iberian origin.

In the case of the Mary Rose we know that she was built in Portsmouth, apparently of local timber (Dobbs and Bridge 2000). Her keel was largely of a different timber to those described above, elm (*Ulmus sp.*). There are several species and subspecies of elm native in England and some recent English boatbuilders are very particular as to which variety they use. Unfortunately ancient elm timber can not apparently be distinguished to species (Tyers Pers. Com.). Thus, we must simplify to 'elm' in the following text.

Four main reasons might be offered for the use of elm; firstly cheapness, elm was less expensive than oak (see Chapt. 9). Secondly, some forms of elm have rather a straight growth habit and can form long lengths of fairly straight timber quicker than oak even in open hedgerow situations. Thirdly, elms resist splitting well when many fastenings are used, as in a keel, due to their interlocked grain. Fourthly, there is evidence for the growth of some very large elms in the fifteenth and sixteenth century in Southern England (Goodburn 1996b Un Pub.)

There is a popular myth that elm is also more durable when waterlogged than other timbers. In practice this is not the case, simply, a timber with moderate natural rot resistance such as elm or poor resistance such as beech will not decay fast when saturated in the bottom of a vessel (Goodburn 1984:139).

An apparently new feature of carvel ship keel construction were the additions of timbers on top of the keel at the stem and stern, the 'deadwoods'. These were usually scarfed, iron clench-bolted and treenailed to the main keel. An example was recently found reused from a mid to early 17th century ship, at Bellamys Wharf, BEY95 (Saxby and Goodburn 1998:187).

Keels in early post-medieval clinker built vessels

Several post- medieval clinker built vessel wrecks have been found in the London region, such as the two vessels from the Lea valley (Fenwick 1978:190), and Blackfriars 2 (Marsden 1971, 1996:145). But only the reused end of a keel from a Magdelen Street, Southwark, MGS96 has been recorded in detail although some information can be gleaned from accounts of the Blackfriars 2 keel.

The Blackfriars 2 keel

A short length of the keel was lifted and examined in detail. It was plank-like, of elm about 200mm wide and 50mm thick, with narrow flanges to which oak garboards were fastened with small iron rove nails. The vessel was slightly built. No toolmark evidence has been presented but clear marks of manual sawing of some type show on the upper face in a published photograph (Marsden 1996, Fig. 140, Here fig. 73b). Thus, it would appear that the keel of the lightly built craft was cut out of a hand sawn 50mm (2") slab of elm. No wood anatomical data was recorded so the orientation of the heart or butt end can not be described.

The keel end from MGS96

This section of the end of a keel from a more heavily built vessel than the Blackfriars 2 boat was found reused in a watercourse revetment currently finds dated to the around 1600 (Chew 1997 Un pub.) It was strongly tapered over its 1.79m length, 270mm wide narrowing to 120mm, a little asymmetrically (fig.73a). Although the timber was damaged in reuse and heavily eroded, traces of a hard brown deposit adhered. On the flanges this was mixed with hair, and the lap with the garboard was fastened with some form of rove nail which had only left quadrilateral impressions. Faint edge tool stop marks survived on the protected flanges and were up to 65mm wide. The orientation of the marks possibly suggested the use of a small adze for shaping the bevel.

The keel was also of elm and the position and orientation of the knots showed that the narrow end was in the crown of the tree close to the usable length. It is quite probable that this keel was hewn out of a thick sawn slab in a similar way to that of Blackfriars 2. The timber had over 50 annual rings and was thus probably cut from a parent tree at least 60 years old and a minimum of 0.4m in diameter at chest height.

7/5 VESSEL ENDS- STEM POSTS, STERN POSTS, OTHER TERMINATIONS AND SECONDARY EVIDENCE FROM HOOD END FORMS

Unfortunately we have very scant evidence from England for the making of the ends of vessels for the early and late medieval periods. This is particularly distressing in that it is generally accepted that the shaping of the stem (fore and aft) was a key feature of early medieval clinker boat and ship building (Crumlin-Pedersen 1986a:220).

7/5/1 PRE-CONQUEST BLUNT ENDS

It is possible that early hulc-type vessels had rather blunt ends above the waterline, judging from the surviving inland finds near Utrecht (Utrecht 1, Water Straat, and Velsen boats) the coin images (Lebecq 1990:88) and parallels with modern hulc-like vessels such as Dutch 'Vlets'. However, we have no hard archaeological evidence (Goodburn 2000a).

7/5/2 PRE-CONQUEST SHARP ENDS FOR KEEL-TYPE CRAFT

Apparently only two stem timbers are known from before 1100 in England, the after stem of the Graveney boat (Fenwick ed.1978:208), and the stem fragment from Vintners Place, VRY89, (Goodburn 1994:100).

The Graveney after stem or stern post

The top end was truncated as found but it survived for a length of 3.3m. The other dimensions can be taken off the published drawings. The maximum width fore and aft ('moulding') was 0.7m, and a maximum thickness along the for'ad edge ('siding) of about 120mm and the reconstructed original length is about 4.2m (fig. 74a).

The parent log and toolmark evidence

The after stem was carefully hewn from a halved oak log, the other half was likely to have been used for the fore stem which was probably roughly the same form. The parent log must have been only slightly curved, fairly knot free and about 1m in diameter towards the butt (fig.74b).

A rabbet was carefully hewn out on each side to receive the plank ends, which were fastened with small iron blind nails and luted with tarred wool. Towards the base rather roughly cut grooves had been made for re-securing several plank hood ends with rove nails as some form of repair (Fenwick ed.1978:217). The broad sides of the stem appear rather worn and abraded, except perhaps towards the rabbet on the port side where a few small axe stop marks may just be visible. The ripples on the face are too wide, rounded and far a part for chatter marks from a shaving tool as has been suggested (Fenwick ed. 1978:217) but are natural ripple grain such as is found in some oaks.

Hewing such a large tapering timber so regularly was a vast amount of work, the timber is one of the most accurately hewn in the whole surviving structure. There was no structural need to make the base of the stem so wide with the use of so much timber and effort. The only explanation can be that the builders wished the vessel's grip on the water to be improved for sailing (Fenwick ed. 1978:217). The comparative quality of the work of shaping this highly visible timber may reflect a wish of the senior builders to show their skill in hewing fair timbers?

Other features

The weakness of the stem lay in the short edge-halved scarf used to join it to the keel which was secured with five rove nails. It was clearly a point of stress in relation to the great bulk of the after stem and had fractured. The holes in the upper part of the stem may have had some rigging function which is beyond the scope of this investigation.

The Vintners Place stem (VRY 89 [5015])

A small fragment of mutilated oak stem was found lying on a Thames foreshore just in front of a low revetment, the tree-ring based dating of the site sequence suggests it was deposited in the early 11th century. It is unknown weather it was part of a fore or after stem. However, several features of interest did survive (Goodburn 1993:101, fig.74c).

It was carefully hewn from a radially split section of straight grained oak with a fore and aft width of about 150mm, and a width on the aft edge of about 80mm. These proportions might suggest it derives from either a large boat or small lightly built ship. A rabbet was cut for the plank hood ends, and two small nail holes survived. No surface treatment or luting material was found, but the leading edge did retain two worn, parallel scratched lines, probably made using some form of 'profile iron'. This type of tool is in essence a form of scraper sharpened with an undulating edge to scrape a shallow moulding along the edges of timbers. They were very widely used in Viking period and later Scandinavia, particularly in Norway (Christensen 1985:209). Only a handful of timbers have been found with such mouldings in early medieval London, including this stem fragment.

The stem fragment had several mysterious holes cut into the surviving face. The large oval hole was clearly worn by the chafe of a rope, ie. part of the rigging of the vessel. The function of the unfinished spoon auger holes is unclear. They may just reflect the use of the timber as a chock which another timber was rested on during a woodworking operation which involved boring. The breakers axe marks are very sharp whilst the original surfaces of the timber were all eroded suggesting the parent vessel was old when broken up.

INDIRECT EVIDENCE OF THE CONSTRUCTION OF VESSEL ENDS IMPLIED BY HOOD END FORMS

Three examples of pre-Conquest hood end boards have been found in London the only examples know to this writer other than those of the Graveney vessel. They were cut to distinctive shapes to meet different forms of stem timber (Goodburn 1994a:100-101). As the fastenings and luting also varied it would appear that they come from vessels built in different styles. Tree-ring study suggests that the three groups of hood ends were made from timber from the SE of England felled in the early tenth century (Tyers 1994a and Pers. Com.).

A straight raking end from Bull Wharf (UPT90 [7250])

Four articulated oak clinker planks were found reused together in a low river inlet wall, the lowest two were in the best condition and were lifted for detailed recording (fig.75a). They were made in the New Fresh Wharf style (see below) neatly hewn to fit a stem that was straight and raking, like that in the Graveney vessel (Goodburn 1994:101). Hood end [7250] appears to have the eroded remains of a scarf suggesting the plank group derived from the port side at the stern.

Small nail holes (c.4mm dia) survived for fastening the boards to the stem even though the lap fastenings were New Fresh Wharf style treenails. Tarred moss survived in the laps only. The ends joining the stem had been bevelled possibly to fit a wedge-shaped, unrabbeted stem. The top corner of the board was cut off roughly square to the line of the rabbet and neatly recessed into the lower edge of the board above, as in the Graveney boat. Although the toolmarks were abraded, it would appear that this was done with an axe.

A convex curving end from Thames Exchange (TEX88 [2412])

A fragment of oak clinker hood end board, in the New Fresh Wharf style (see below), was found lying horizontal in the land-fill behind a low timber river wall at the TEX88 site (fig.75c). The curved end that joined the stem, either fore or aft was slightly damaged but several features are clear. The stem was almost certainly convexly curving and the original fastenings were at least partly treenails. The edge of at least one nail hole also survived but this may have been a repair. As the ends of the planks were noticeably bevelled to fay against the stem it may have been a plain wedge shaped timber or possibly some form of winged stem (figs.2,).

A convex curving end with a 'multiple end plank' from Bull Wharf (UPT90 [7469])

A slab of articulated but crumpled oak clinker planking was found reused in a river inlet wall on the UPT90 site. The distorted boards, which were clearly always less than 20mm thick, were reassembled to give a 'best fit' (fig.75c). The slightness of the timber may suggest an origin in a boat rather than ship. Indeed the best parallel may be the arrangement used in the stern of the mid 12th century Gislinge boat, from Denmark. This vessel was about 8m long with a beam of 1.5m (Gothche 1993, fig. 75d). As the scarfs in the ends of the boards face both ways it is unclear weather they derive from a bow or stern. The reversal of one rove nail suggests that there was little space to clench the nail ends. One of the boards was shaped to simulate the ends of two strakes. A feature which has been called 'multiple end planks' (McGrail 1993:42). Several of these were found in Hiberno-Norse Dublin eg. T353 (McGrail 1993:45), but none are exact parallels.

The next strake up was fastened with oak wedged willow treenails and may well have been the 'sheer strake'. As the laps were originally luted with fine tarred hair but had latterly been caulked with tarred moss, the vessel may have moved from one boatbuilding region to another. Faint traces of a fine scratched moulding were also seen on the outboard edge of the upper plank. The short repair board joining the multiple plank end to the top strake was not moulded. The exact original stem shape implied by this assemblage is unclear but it must have been convexly curving at least towards its upper end.

In sum, there is evidence of both straight raking ends and convex curving ends being used in clinker keel-type craft before the Norman Conquest.

7/5/3 POST-CONQUEST AND POST-MEDIEVAL WITHOUT STEMS

Again a dearth of archaeological finds from England is a problem here even though historical and iconographic sources show various types of square ended vessel were in wide spread use on the middle Thames by the 16th century if not earlier. Indeed, although a section of the hull of one such square ended barge of c. 1580 has been found very recently the very ends of the vessel were not preserved. But enough survived to show that it would have had a sloping square or 'swim' bow of some form (MFB98 entry in Append. 6).

7/5/4 POST-CONQUEST ENDS WITH STEMS

The published material evidence for stem construction in England in later medieval times is slight. Descriptions are available of the truncated stems in the Blackfriars 3 wreck and several stored rough-outs and one used stem are reported in detail from the Iron Foundry boatyard site in Poole, Dorset. These are discussed below with some secondary evidence such as the articulated hood ends from the Kingston vessels.

The stems of the river keel or 'shoute' Blackfriars 3

The stems were edge halved scarfed to the keel ends (fig.76a). The short, crude vertical, through-splayed scarf in the stern post may have been a repair ? Sections of oak grown to shape were hewn down to the form required, but the conversion type is unknown. The cross section was flanged in the manner of the keel initially, grading into an unrabetted, wedge-shaped profile higher up. The photographs taken in situ show that the inboard faces of the timbers were well rounded and also tapered down in thickness as the timbers rose from the keel.

The stern post was strengthened and differentiated from the stem post by having been fitted with a thin band of iron along its aft edge, running round to just short of the keel scarf (Marsden 1996:65). Contrary to the view of Marsden this writer sees this as evidence for the hanging of a stern rudder.

The used stem and 'under lout' stock piled at the Poole Iron Foundry site and the application of a new technology

The late medieval boatyard timber store excavated at the Poole Iron Foundry Site will be discussed in more detail in chapter 8 (Watkins 1994) here we are only concerned with the used stem and intermediary timber or 'under lout' (Hutchinson 1994b:30). These oak timbers ([46]a,[46]b) were found articulated, joined at the vertical, stopped-splayed-scarf (fig.76b). This was fastened with a combination of rove nails and small spikes, and luted with yellow material (resin??) and moss. The same type of scarf was used to join the under lout to the keel. The square ended garboards over lapped and strengthened the keel to under lout joint. The whole stem was just under 2m long and 250mm fore and aft at the base, with a maximum thickness of only 65mm and was slightly wedge shaped and un-rabetted. The outboard edge was bevelled away for streamlining. The hole through the sides of the stem at the top must have had a rigging function whilst the hole through the under lout was probably for hauling out.

Evidence for how the stem was made

Allen recorded some of the wood anatomical and tool mark information, and there is much of interest here (Allen 1994:41 and Pers Com.). The two timbers were tangentially converted, and the scarfs hewn out. It is not noted how the accurately cross-cut ends were made but the edges of the timbers were trimmed with an adze on the concave edges whilst the tool marks drawn suggest the use of an axe on the other edges.

Although it is not suggested how the timbers were initially converted, the process can be partly reconstructed from the drawn evidence. The oak stem and under lout rough-outs with which the stem assembly was found were sawn out. The saw marks shown on unpublished record drawings of one of the rough outs [43] (kindly made available to this writer by S. Allen) indicate that a roughly axe trimmed, curved log was sawn into at least two, possibly four, curved slabs (Allen 1994:41). The sawn slabs were then clearly trimmed with axes and adzes to produce elements such as the used stem and under lout under discussion here.

The saw marks do not show signs of crossing over indicating sawing from both ends, as in early methods of sawing on one or more trestles (Goodburn 1992:114, 1997a:34, 1997b, and Append. 4d). Thus, the slabbing must have been done by pit-sawing, where the marks travel to the end of the kerf sloping in one direction only. This is an early example of the use of such a sawing method in any woodworking context in England. The method has two principal advantages, several almost identical roughed-out timbers can be produced; certainly enough for the stem and stern post of one vessel if not two. These points are expanded upon in chapter 9. Sawn stem elements are also known from other medieval nautical finds such as the late 13th century Gedesby Ship (Bill 1999) and the very recently found Roskilde 1 ship, tree-ring dated to the mid 14th century (J. Bill Pers. Com.).

THE END FORM IMPLIED BY LATER MEDIEVAL HOOD ENDS

Sections of hood ends survived from two of the Kingston Horse Fair finds No1 and No2. Those from the No 1 boat are the best preserved.

The Kingston Horsefair (HOR88) No1 boat hood ends

Two sections of articulated oak hood ends survived from the vessel broken up for reuse in a river wall, the tree ring dating suggests the timber was felled in the early 14th century (Goodburn 1991:109-110, Tyers 1997 Un Pub.). One section [529] appears to derive from fairly low on the port side whilst the other section, ([445],[447]) was from the upper hull, either the port side at the stern or the starboard side at the bow (fig.76c, 87). Both the slabs of boards were axe cut to fit a raking, convexly curving stem. The upper corners of the boards were hewn to a rounded feather edge and set into a slight hollow in the lower corner of the upper board. This meant that the ends would be robust but lie flush against the stem. The back bevelling of the ends shows that the stem was probably a simple wedge-shaped form with no rabbet or only a shallow one, similar to those used in Blackfriars 3. Indeed the parent vessel may have been a rather similar river keel or 'shoute'.

7/5/5 EARL POST-MEDIEVAL VESSEL ENDS WITH STEMS AND STERN POSTS

By the 16th century the differentiation of the ends of English vessels large and small seems to have become more pronounced such that the modern English terms 'stem post' and 'stern post' seem more applicable. The profiles of some differentiated ends are shown in Thames panoramas such as the sixteenth century Agas Map and rather more so in slightly later views such as that of Vischer made in 1616.

Unfortunately the stems and stern posts of vessels of this period, were either poorly preserved or not investigated as was the case with the Cattewater ship and Blackfriars 2 boat. Thus, a few general comments may suffice. With the increase in complexity and size of sea going English ships starting during the later 15th and developing greatly in the 16th centuries end structures also expanded and developed. By the 17th century when the archaeological evidence becomes more common large carvel built ships might have over five great timbers integral to a stem or stern post and many supporting knee-like braces. Reused composite large ship stems from the early to middle 17th century have recently been found in London but are outside our date range here (Saxby and Goodburn 1998). However, it is clear that a new rather specialised skill had to be developed by shipwrights building these craft that of boring very long holes accurately through the edges of great timbers for the iron bolts, drifts, and treenails that held all together.

Stems and stern posts in smaller craft

The only archaeological evidence known to this writer is that of the single piece Caldecotte boat stem (Hutchinson 1994a:127). However, more complex assemblies should be found in due course.

7/5/6 A 16TH CENTURY SECTION OF REVERSE CLINKER HOOD ENDS FROM MORGANS LANE SOUTHWARK, MOR87 ?

A section of articulated hood end clinker boards was found reused in a moat revetment of the late 16th or early 17th centuries at Morgans Lane, Southwark. The tree-ring analysis shows that the boards derived from trees felled within the region in the late 16th century (Tyers 1996a:198). The boards were of radially cleft oak, heavily tarred outboard and fastened with iron rove nails (Marsden 1996:136). Four principal strake ends survived (fig.77a) at one end they were clearly sawn across probably (?) for reuse but the other retained the broken slightly bevelled ends that would have joined a stem. These appeared to slope slightly in the 'wrong' direction (although only one is intact), ie. they would not match a stem or stern post raking outward as in most recent English boats. Marsden has suggested that the slab of planking derives from a boat built in an otherwise unparalleled style of construction 'reverse clinker' (Marsden 1996:136).

This implies quite enormous innovations in building procedures. In reverse clinker building of vessels with stems in recent times in England, the sheer strake must be fastened first on to stems held within an elaborated jig (set of moulds), normally upside down. The technique is known in the 20th century for some sailing dinghy and speed boat building but does not seem to have a traditional or historic pedigree in Europe, although it has been seen in vernacular boat building in other parts of the world (Blue 2000).

An alternative origin in the 'apple cheeked' ends of a bluff lighter or barge

An alternative explanation might fit the evidence better and does not require the sudden emergence of a totally new boatbuilding technique. The bows and sterns of some of the vessels shown in the 17th century Thames panoramas (eg. Hollar 1647, reproduced in Marsden 1996:157, here fig.77d), are clearly 'apple-cheeked' and 'tumble-home', that is they are bluff, strongly convex and curving inboard at the top. This archaic feature can still be seen in some vernacular craft of the Low Countries, English Fen lands and the inboard curving hoodends on traditional English narrow boats. Indeed in some reconstruction drawings of Blackfriars 3 Marsden shows inward curving hood ends in the sheer strake (Marsden 1996:82). This shaping of the ends has the effect of producing the 'wrong' slope to the ends of the top few hood ends as they are set inboard against a widening stem or apron. The lack of luting noted in some of the plank laps (Marsden 1996:141) might also be expected in some of the uppermost laps, way out of the water where a lick of tar may have been considered sufficient.

Thus, the stem shape implied by this articulated section of hood ends, which was strongly convex when found, is markedly convexly curved or 'apple cheeked', to the extent that the upper hood ends slope inboard (fig.77b). If this interpretation is correct the parent vessel would then have been built in the conventional clinker style. Making the extreme bends in these boards was one of the builders great skills, and traces of charring recorded (Marsden 1996:144) may suggest how this was done using fire (see below).

Another strong alternative explanation is that the panel of clinker boards actually derives from the upper works of a large early post-medieval ship such as the Mary Rose or Vasa (O. Crumlin-Pedersen Pers Com. and fig.77c.).

7/6 HULL PLANKING, SELECTED EXAMPLES AND CHANGES THROUGH TIME

The most commonly found parts of planked vessels of our period are hull planks or boards. These vary from small isolated fragments to sections of articulated clinker boards over 14m long (Append.6.). These larger articulated hull sections appear to warrant reference as 'boat finds' in the same manner as some wreck finds where a similar amount of material may survive. The larger most distinctive of these slabs (eg, the Kingston No1 boat Goodburn 1991:108). Does provide some information about the size shape, form and function of the parent vessel (fig.78) but the primary focus here is evidence of working methods and raw material selection and production (see Chapts. 1,2). Even sections of hull planking less than 0.5m long can provide useful information in this context.

Before proceeding to summarise key features of the material examined for this study (Append. 6 summarises the volume and character of the material) some essential terms and concepts must be explained, as there is confusion in some of the literature.

7/6/1 THE TERMS 'STRAKE', 'BOARD' AND 'PLANK'

There is often confusion in the literature as to the meaning of the terms 'strake', and 'board' or 'plank'. The meaning of the word strake in recent English boatbuilding usage is; a line of planks or boards (Occasionally one board or plank) that runs most or all of the length of the hull. It is analogous to a 'course' in a brick wall. Only rarely will the strake be in one piece, and so the boatbuilder or shipwright works with component parts, boards or planks. Scarfing boards together then treating them as one element seems to have been a recent practice in very small scale work only (eg. Leather 1973:86). In traditional shell-built craft in recent times some or even all of these boards had separate names (Gothche 1985:33, Horridge 1982:60, Osler 1983:57). Thus, the key elements reflecting hull shape, the strakes, are themselves sub-divided.

The terms 'board' and 'plank' are almost synonymous in modern English although in medieval documentary sources they are often distinguished, although the rules for this distinction are not altogether clear. In some sources, where we can be reasonably sure that radially cleft material is referred to the term is 'board', 'ship board', or explicitly 'clove board' (see chapt.8). The term 'plank' or similar seems to imply thicker material which would have been sawn in later medieval times (Goodburn 1997a, and notes in Append.6 TYT98 entry).

7/6/2 METHOD AND TYPE OF CONVERSION

The importance of the issue of the conversion methods used to produce planking for vessels has been discussed in outline by several nautical archaeologists, (eg. Olsen and Crumlin-Pedersen 1968:153, Christensen 1985:213, Crumlin-Pedersen 1986a:218, and McGrail 1987:37). It has become apparent that there were changes in the methods used through time and space from Pre-Conquest times to 1600 AD and beyond. The details and implications of these changes develop hand in hand with economic, technical, cultural and environmental changes (Chapt. 9).

Any study of these changes must be based on clear documentation of distinct features of conversion;

1/ the section of log used or 'type of conversion',

2/ the way the raw material was produced (eg. see-sawing from a hewn baulk, or hewing from a log cleft in half etc.) or 'method of conversion'.

The distinction is important for example, a hull plank may have a 'tangential face' (Append.2) but this may be produced using a variety of methods depending on the date, style of vessel, and other factors such as location. The methods of conversion documented in NW European finds for our period are briefly reconstructed below. For fuller technical details of hypothetical conversion methods tested experimentally see Appendix 4. It is not necessary to provide an extensive summary of laboratory wood science as it bears on this subject as this has been provided by other authors (eg. McGrail 1987:24-27). The practical effects of certain aspects of timber structure are what is dealt with here.

7/6/3 TANGENTIAL CLEAVING: OR PLANKS AND BEAMS FROM LOGS SPLIT IN HALF

A process sometimes called confusingly called 'tangential cleaving' is in essence the processes of splitting a log in half evenly. Each half then had to be hewn and split down to make a plank or beam section timber. Of course many types of plank keel were also made this way (see above). With large oak logs the wedging must be carried out evenly and steadily from either both sides or from the end and one side for a successful halving .

Advantages of the method

The method allows most of the diameter of the parent tree to be used. It is also, in practice, easier to produce long planking this way, and use smaller, less regular, more knotty parent trees than for radial cleaving.

Disadvantages of the method

Disadvantages include a tendency in planks of this type to split somewhat in the middle during seasoning, and have greater overall movement in changing conditions of humidity. The labour of hewing and splitting off the waste outer surface of the log must also be considered. Vessel planking of pine (*Pinus sylvestris*) and ash (*Fraxinus excelsior*) were typically made this way in early medieval times as was found in places in the eleventh century Skuldelev vessels, particularly Skuldelev 1 (Crumlin-Pedersen 1986b). Several reused boat planks from Hiberno-Norse Dublin were also of pine converted in this way (McGrail 1993:42).

Part of the orloke strake of the Galley hull fragments found at site TYT98 was made from a tangentially faced plank of beech that was rather weathered and had few surviving toolmarks. However, it did have a lentoid cross section and some faint axe stop marks suggesting that it may have been hewn from a half log (Goodburn Forthcoming d) .

The method was used for particularly, long and broad oak planks, as in some of the upper planking of Skuldelev 3 (Crumlin-Pedersen 1986:147). However, the tendency for oak worked in this way to distort and split can be clearly seen in the split and repaired eleventh century wale plank from Fennings Wharf, Southwark (FW84, Marsden 1994:158). Indeed nautical planking converted by this method is very rare in the English corpus, despite the method being widely used on land until about 1220AD (Goodburn 1997b). However, it is also just possible that the planking of the 'Frisian' boat (From BUF90/UPT90) discussed below was made this way, but the evidence is uncertain due to the weathering of the surfaces and a sawn origin may just be possible if very unlikely (Goodburn 2000a).

7/6/4 RADIAL CLEAVING

In the vast majority of medieval planked vessel finds discovered in England the hull planking or boards were of radially cleft oak. Both the NW European oaks (*Quercus, robur*, and *Q. petrea*) and closely related beech (*Fagus sylvatica*) have very marked natural planes of weakness along their medullary rays. This characteristic was widely exploited from Neolithic times to produce both wedge-shaped beams and thinner boards. On current evidence (see below) the production of wide boards by this method for boat and ship building died out sometime in the 17th century in England (Chapt.9). The craft has had to be relearned by experiment (Append. 4). Much serious experiment in the field of producing radially cleft oak ship board started in Denmark just over 30 years ago and since about 1980 the work has been closely based on detailed studies of the ancient material (eg. Vadstrup 1984:91, 1997:89). In England, in non maritime contexts, radially cleft oak house boards have been produced by Darrah and others for early medieval building reconstructions since the late 1970's (Darrah 1982). A step by step summary of essential features of the process are described above (6/10) and shown diagrammatically and photographically in figures 60 and 80. Appendix 4 summarises aspects of first hand experimental work in this field which informs this study and briefly covers variations in experimental methods used. For brevity readers are referred to the sections noted above for general information, whilst a few additional details are discussed below.

Some details of the experimental replication of medieval radially cleft shipboard not covered in section 6/10

As many boards can be produced from one large, suitable oak log the total number of logs used for the boards for a particular ship may be quite small. For example, it has been suggested as a result of visual checking and initial tree-ring analysis that only three or four trees were used for the Graveney boats boards and a similar number for most of the Skuldulev 3 planking (Fletcher 1978:115, Crumlin-Pedersen 1986:218). This likelihood has been subject to testing by intensive tree-ring sampling and 'same tree' matching in the case of the 13th century Magor Pill vessel. Here two parent trees were found to have provided many of the boards and at least one floor timber (Nayling 1998:117). Experimenters have rarely been able to match the archaeological or historically attested (8/1/1 below, Carr Laughton 1957:247) rates of board production per log of up to about 30. Key reasons for the greater historic productivity may have been the typically slow, very even growth of nearly all the parent trees used for early medieval oak shipboard and a greater original parent log size (table 1). Slow grown oak (annual rings less than 2mm wide) is comparatively light, easy to work, and cleave compared to the typically fast or medium growth, tougher oak available today in Western Europe for experimental purposes. Simply it was easier work then than it is now.

Wedges of wood or metal?

Cleaving can be achieved using wooden mauls and wedges alone (Append. 4.), but using an old axe or ferrous wedge usually starts the initial split more easily and enables minor steering of the split direction. However, using large ferrous wedges and sledge hammers tends to make clear pressure marks in places on the resultant boards and these have not yet been recorded on barely trimmed cleft boards found in Greater London. The cost and weight of several ferrous wedges may also have been prohibitive. On balance it seems most likely that most of the wedges used would have been of hardwood, with one or two ferrous wedges, or an old axe for starting (Olsen and Crumlin-Pedersen 1968:160).

Advantages of the using radial cleaving as a method of conversion

As the planes of weakness in the oak are parallel with the faces of the material it is much more stable in changing humidity. In practice green, radially cleft oak will shrink only about half the amount that tangentially faced oak will (McGrail 1974:51). It is also stronger than radially or tangentially sawn material as the grain is followed during the cleaving.

Radially cleft oak boards can usually be distinguished from quarter sawn by slight irregularities in the surfaces, areas of torn 'as cleft' grain and axe marks from trimming as well as lentoid, wedge shaped or sculpted cross sections. Fastenings are also less likely to cause splits.

Disadvantages of the radial cleaving method

The method has very high specifications for parent logs which have to be large (0.8m - 1.0m +dia.) straight, almost knot free, butt logs, from what are sometimes called board trees (Goodburn 1992a:125). Experiment shows that the width of a finished radially cleft board is equivalent to only about 30-40% of the full diameter of the parent log. For example, a radially cleft shipboard about 0.35m wide requires a parent log of around 1.0m mid length diameter. By contrast a tangentially sawn or half log cleft plank of similar width can be made from a knottier, less straight, much smaller log only around 0.5m diameter at mid length. Board log parent trees have to grow in high dense woodland or as least groups of other tall trees if boards much over 2m long is required (Goodburn 1992a:118, and Chapt.9). Even for shorter boards logs require careful selection.

Radially faced board is also slightly less easy to bend and twist than tangentially faced material. But this difference in handling would only be apparent in very full-ended craft with extreme hull bends.

SOME TRENDS IN SHIP AND BOAT HULL BOARD AND PLANK MAKING DERIVED FROM SELECTED EXAMPLES OF C. 900-1600

Typically large early medieval boards

The typical early medieval shipboard parent trees were slow grown often being 200-300 years old and around 1m diameter at chest height, these features suggest an origin in 'wildwood' type conditions (figs. 81b, and 82, Goodburn 1992, 1994b, 1998, Peterken 1996:150,). Radial shipboards up to 6m long and over 400mm wide are known from the Danish Skuldelev 3 vessel, but they were typically a little narrower and shorter in the Graveney boat found in N. Kent (Table 1). The longest early medieval, radially cleft shipboards known from N Europe are the c. 10m long examples in the 10th century Hedeby 1 longship (Crumlin-Pedersen 1997:86). The wider implications of the use of this exceptionally large material are examined below (9/4), and few could argue with the suggestion that such materials reflect high status and preferential use of very valuable materials (Crumlin-Pedersen 1997:93).

Shorter and narrower later medieval and 16th century cleft shipboard

The late-medieval London cleft shipboard finds are generally much shorter, and a little thicker in proportion to width. A trend clear in the three Kingston finds for example (Table 1, fig.87). By the late 13th and 14th centuries boards over 3m sold for a great premium (Chapt.8/1/3). The later boards (of home origin?) have often been found to be derived from much younger parent trees, some having less than 50 annual rings, too few for tree-ring dating or provenancing (Table 1).

The reduction in size reached extreme proportions in the oak boards used in the late sixteenth century and early 17th centuries. For example whole selections of articulated clinker boards from the middle sections of hulls from the JAC96, and MGS96 sites in Southwark, (fig. 84d), were under 2m (6'6") long and only around 150mm (6")wide.

Clearly the size, age and shape of the native parent trees used had changed very considerably in that 400 year period (9/5). But a complexity here is that wildwood oaks from elsewhere in Europe were still being exploited well into the post-medieval period. Fourteenth century shipboards from the SE Baltic wildwoods have been found reused at the SYM88, and ABO92 sites at Hays Wharf, Southwark and in York and Great Yarmouth (Table 1, Tyers 1996a:196, and I Tyers, C Groves Pers. Com.). In the York example they were used with local boards (Goodburn 2000b). Apart from ease of working, a lower cost may have encouraged the use of SE Baltic boards. For example, 10' 'Estricheborde' (SE Baltic) boards were 2d each in 1329 (Salzman 1952:245), whilst earlier in 1294-6, apparently local 8' boards where the same price (8/1/3, table 6). Shipboard of Irish wildwood origin has also just been found in England in conformation of historic references to Irish shipboard exports in the 12th- 13th centuries (Hutchinson 1994a:150, Append.6, TYT98 entry, and Tyers 1999).

Shipboard was made at a distance from later medieval and 16th century ship and boat building sites

With the extinction of any sizable tracts of wildwood type woodland in England by the mid 13th century (Rackham 1976: 64, Goodburn 1998) and regionally earlier than that, locating suitable board trees must have become very much more difficult. Groups of such trees are likely to have often been at great distance from the point of demand. English documentary sources from the late 13th century onward make it plain that the vast majority, if not all boards for clinker built hulls large and small were bought in by shipwrights, not produced by them (Chapt. 8/1/1). This is commensurate with the practical and logistical understanding gained from experimental work which shows that moving roughed-out boards or perhaps sections such as trimmed 1/8's, is far more likely than moving the large, very heavy parent logs or even 1/2 or 1/4 sections. A typical green board log 1m diameter would have weighed around 0.82 tonnes/m whilst a roughed-out, green, board 350mm wide, 30mm thick and 3m long would have weighed only about 33kg or less after some drying. Even the largest documented oak shipboards would have only weighed just over twice that (McGrail 1993:42). Once roughly trimmed, boards could be more easily stowed and transported over long distances.

Radially cleft oak boards of various types were important trade commodities of the Hansa merchants who carried them from the SE Baltic to western Europe (Salzman 1952:245). A fifteenth century part cargo of such roughed-out boards for export has been excavated and is displayed at the Polish National Maritime Museum, at Gdansk. The slow grown oak boards displayed were all under 3m long, rarely over 350mm wide, and only very roughly trimmed. Considerable further trimming would have been required for nautical use (fig. 89).

Documentary sources show that boards produced in SE England and imported from the SE Baltic were both used in similar later medieval vessels sometimes side by side. However, the work of Tyers has shown that vast majority of analysed clinker shipboards found in the London region appear to have been produced in the SE of England (Tyers 1991, 1994a, 1996a). Whereas a much larger proportion of none nautical boards such as door leaves, and panelling in buildings were of SE Baltic or German timber. This may suggest a preference of some shipwrights for faster grown, stronger, greener (and more flexible) local material.

It is well known to practical woodworkers that fast grown oak (av. ring width 3mm+) is denser, stronger, less easily split and more durable than slow grown material. Where timber has to be bent or hewn, as in most forms of boat or ship building, green or semi-green material is also much more easily worked.

The orientation of the boards in use

It might be expected that the thinner heart edge of radially faced boards would be orientated in a regular pattern, placed downward. In practice with wide thin boards it is often very difficult to see which is the heart edge, and where this has been closely studied, such as for the later medieval Kingston 1 boat no clear pattern was found as was also the case in some of the Dublin finds (McGrail 1993:40). However, Fletcher noted of the Graveney boat's boards that the thicker outer edge in the log was set uppermost (1978:113).

7/6/5 HEWING AND SMOOTHING ROUGH CLEFT BOARDS AND TRIMMING LAPS, AND SHAPING SCARFS

Typically most reused shipboards and many boards in wrecked vessels are found to have abraded surfaces except in scarfs and laps. Thus, the toolmark evidence for how the faces of the boards were finished has usually disappeared. Christensen has also noted that the outboard faces of the strakes of many early medieval Scandinavian finds were carefully smoothed possibly with some form of shaving tool, whilst the inboard faces were typically rougher (AE.Christensen Pers. Com.).

Radially cleft oak boards have been found in 12th century river wall sheathing which have not been thoroughly smoothed and trimmed (Goodburn 1997b). The surfaces had large areas of torn grain and irregularities that would have made them difficult to use for boat or ship building without more trimming (Fig. 90 h). All cleft medieval shipboards examined for this study had been dressed much smoother and nearly all the irregularities removed leaving at most only small spots of as-cleft surface . It is almost certainly the case that this further trimming and smoothing would have taken place at the construction site (9/4/6 below).

THE PRE-CONQUEST EVIDENCE

A systematic presentation of surviving toolmark evidence on board faces with illustrations to scale has not yet been published, although several authors have contributed notes, observations and occasional photographs. The most useful of these has been the publication of photographs of the inboard faces of some of the upper cleft strakes of Skuldelev 3 in situ (Olsen and Crumlin-Pedersen 1968:160, Crumlin-Pedersen 1986a:223). These show axe stop marks orientated at about 45 degrees along each side of the plank faces (roughly herring bone fashion), the size can not be seen clearly but the marks are noted as small. This patterning shows that the board was held on edge and the upper half of the face trimmed working along the grain at about 45 degrees to the long axis, then turned on to the other edge and the other half of the face trimmed (fig.82e). This approach to hewing automatically tends to produce the lentoid section boards noted in this vessel. This method of hewing is also well suited to tangentially cleft boards as the grain direction may vary either side of the pith. The lack of documented wide broad or 'T' axe marks on the boards of the vessels excavated at Skuldelev is probably a function of the weathering and abrasion of the timbers. On the other hand it may be that the traditions of board making in oak, pine and ash are typical of central Scandinavia, and that wide 'T' shaped broad axes are more typical of areas to the south? It is very difficult to be certain but the smooth flat surfaces of the massive radially cleft oak boards of the Hedeby 1 long ship appear to have been smoothed with T axes like the one found at the port site.

Very broad bladed 'T' axes appear to have been used to trim and smooth radially cleft boards, both in nautical and land woodwork in SE England. The stop marks from such tools appear almost straight up to about 300mm long and 50 degrees to mainly parallel with the grain, such that they may easily be mistaken for scratches or splits along the grain (fig. 82b). The reason the marks are almost parallel with the grain is that the tool flattens and trues a rough hewn green surface most effectively used at almost directly across the grain (fig.80c).

Observations on the evidence for the shaping and smoothing of the Graveney boats boards

Some observations were made about how the Graveney boat's boards were hewn one of which was particularly perceptive and important. It was noted that in some cases the end of a board might not be a true radial section (Fenwick 1978:228) and that this might be due to considerable hewing down of a slightly twisted cleft section. Alternatively it could also be due to hewing in a twist into straight cleft sections (see below). In experimental cleaving, where the aim has been to produce flat, straight boards, considerable amounts of hewing are required when the cleft section is slightly twisted. One end or sometimes both, of the resultant finished board then has a slightly off-radial face. This phenomenon was also noted with some of the planking of the Kingston 1 boat.

It was suggested that the Graveney boat's boards may have been hewn with 'axes and adzes' (Fenwick 1978:228), but the illustrated toolmarks are clearly axe stopmarks from tools worked at about 45 degrees along the grain. Given the evidence for the wide spread use of various types of axes elswhere at this period (Goodburn 1997b) it is very unlikely that adzes were used. It is important to note that Graveney's planking was slightly wedge shaped in cross section and not lentoid . On several of the reproduced tracings of the sides of the frame timbers of the vessel (Fenwick ed. 1978) there are straight marks that could well be scratches or may in fact be T axe stop marks.

The evidence from the fragmentary pre-Conquest London finds

The fragmentary pre-Conquest clinker shipboard finds from London have been too worn and decayed for clear surface details to survive on the board faces, although slight undulations on the best preserved show that they were cleft and hewn. However, in the protected areas of the laps clear marks sometimes survived. For example two late 10th to early 11th century boards with treenailed laps, [5725] and [5732] from site VRY 89 had axe stop marks that were almost parallel with the lap edges and 200m long only slightly curved (fig.82a). The blade used must have been at least 220mm wide very fine and almost straight, which would suit the general characteristics of contemporary T axes. In these cases the laps were not shaved in any way after paring blows with the broad bladed axe. It is presumed here that the same form of tool was used to dress the faces of the boards as in radially faced building clapboard of broadly the same date (Goodburn 1994 Un Pub.,1997b and fig.82b).

Some locally made Scandinavian style longship boards from the same site also reused in the earlier 11th century had better preserved surfaces (fig.82c). Two faint scratched lines survived along both the inboard and outboard edges as a shallow mouldings. The rest of the surfaces seemed rather smooth implying very careful 'T' axe hewing and probably some form of shaving. Shaving or scraping of the laps has been clearly recorded in some of the boards from the Skuldulev finds (Crumlin-Pedersen 1986b:141).

SOME LATER MEDIEVAL EVIDENCE

Evidence of how the boards used in later medieval English clinker vessels were dressed has not generally survived or been recorded. However, some of the late 13th century radially cleft oak repair boards found in sections of the articulated galley planking from site TYT98 are an exception. Although the vessel was apparently built in Ireland she was clearly heavily rebuilt in southern England or SE Wales as shown by the use of beech timber (see above and Goodburn Forthcomingd). The almost straight axe stop marks on the rather crudely finished short repair boards were clear but incomplete at 190mm wide. The blade that made them was probably at least 210mm wide and must have been a form of broad axe possible of T axe type.

Again marks tend to survive best in protected areas such as laps, under tingles, and in scarfs. In Kingston 2 some of the last radially cleft oak tingles fitted before the vessel was finally broken up, bore faint rather incomplete axe stop marks and traces of 'as-cleft' surface. Otherwise axe stop marks were recorded on the laps of all the Kingston vessels and a shipboard reused in a 14th century context at Abbots Lane 92 (ABO92 [5304], fig.83a). The orientation of the stop marks and striations left by small nicks in the blades showed that the fine bladed axes were used at angles varying from 45 degrees to almost 90 degrees across the grain. The longest marks were incomplete on the ABO92 board, at about 120mm and had a moderate curve, implying the use of an axe with a fine blade with a moderately curved edge at least 130mm wide. The best preserved marks on the Kingston boat material were on board [509] where slightly curved axe stop marks up to about 140mm long were found on laps and in a scarf (fig.83b). The axe used must have had a fine blade about 150mm wide.

On the 13th century sawn cog-type planking from PLS94 clear marks of a rather straight bladed axe used at 45 degrees survived on both the plank edges and in the scarfs (Goodburn 1997a:28). The marks were incomplete with the longest being 75mm implying the use of a rather narrower bladed axe of a minimum of about 100mm wide (fig.83c). Occasionally fine 'chatter marks' were also found in the laps of the Kingston 1 boards (eg.[454]), which suggests fine trimming with some sort of shaving or scraping tool but in other case the la or 'land' was left axe pared.

SOME EARLY POST-MEDIEVAL EVIDENCE

The 16th and early 17th century radially cleft oak clinker boat boards examined in detail from London have undulating surfaces suggestive of some form of hewn finish but no clear axe marks have been recorded. In some cases the faces may even have been planed. However, axe or possibly adze stopmarks have been recorded on laps and in scarfs on the sawn elm planking that was used with oak in the 16th century. One of the reused boards with the best preserved marks was the sawn elm hull plank [34] from MOR88 (Marsden 1996:170). These marks on the lap and scarf were more curved than those describe above and the widest was only 60mm. Although it was not complete the tool used was unlikely to have had a blade greater than about 100mm at the outside (fig.84a). On a scarf in a similar elm plank from VIY97 the best preserved stop mark was wider, 65mm with one corner preserved showing the use of what was probably a small axe with a slightly less curved blade (fig.84b). In the slab of reused clinker planking from the Rotherhithe site of BEY95 (fig.84c) one of the clearly sawn oak planks had been partially hewn to a wedge shape where it joined what appeared to have been a radially cleft board. This may have been done to reduce weight and the length of lap fastening needed?

THE ISSUE OF SEASONING OF CLEFT SHIPBOARDS

It is the received wisdom that the boards used in medieval clinker boat and ship building were used 'green' (eg. McGrail 1987:27). However, this view needs qualifying as practical experience shows seasoning is a question of degree, a piece of timber may be cut from a log from a tree felled that day, or a week or a month before, or it may be worked to a finished board whilst green then allowed to season or dry through delays in transport, stockpiling and use. Clearly all roughing out work would have been carried out on green material as oak timber is several times as easy to work with hand tools such as axes and adzes when in fresh condition, than after appreciable drying. However, medieval shipwrights could only use totally green boards if they were made on site or close to it. Whilst this may possibly have been the case with some pre-Conquest building, in later medieval times this was not the case (see above) and some degree of partial seasoning of the boards would have inevitably occurred between cleaving and fitting into a vessel. Indeed, this may even have been the case during pre-Conquest times if the much used illustration on the Bayeux tapestry can be believed (fig.81a). The woodworker shown has stacked roughed out boards in the crown of a tree where they would catch the wind and sun and dry rapidly. By contrast, this practice would actually split and warp sawn oak planking badly, where drying must be slow and even.

There are also hints that a small degree of seasoning is advantageous in technical terms, bending can be easier in slightly dried timber than totally green, and shrinkage in use would also be a little less. The absorption, of surface treatments such as wood tar would be better as the surface cells would not be bulked up with sap. In sum, it is reasonable to suggest that boards used for clinker work in medieval times were generally slightly seasoned before being assembled, although they might be considered 'green' by recent joinery standards of air drying at 1 year for every inch of thickness.

7/6/6 THE METHODS USED TO MAKE SAWN SHIP AND BOAT PLANKING 13TH TO 16TH CENTURIES

Early sawing methods used in nautical work have not been much investigated. A few partial exceptions include (Christensen 1985:213 re- post-medieval practice in Norway, Rival 1991:134, Arnold 1992:42 re-Roman methods,). Christensen initiated the consideration of some of the social, economic and environmental factors effecting and effected by the introduction of sawn planks into boatbuilding (see Chapt. 9).

The general presence of saw marks has been noted on some later medieval and early post-medieval nautical timbers in NW Europe, but no reconstructions of the sawing methods used has been attempted. An exception is the cog-style planking from the Westminster, PLS94 site (below and Goodburn 1997a:34). There were several methods of manually sawing out plank known in Europe as late as the 20th century other than the well known 'pit-sawing' technique which dominated in England from the 15th century. Clear evidence of the use of three of these methods in Roman Britain has been found on excavations in London (Brigham and Goodburn et al 1995:43). But there are no well documented cases of the use of saws for cutting along ('ripping') or across the grain in any type of large-scale woodworking in England after ca. 400 or before about 1180AD (Goodburn 1992a:113, 1997b). This statement is based on the examination of literally thousands of excavated timbers.

The focus of attention here is hull planking but the basic techniques would be essentially the same for the production of other long elements such as wales, and stringers.

SOME LATER MEDIEVAL EVIDENCE

Planking for cog-type craft

Currently the earliest clear evidence of the use of sawn plank in post-Roman nautical woodwork in England is the early to mid thirteenth century cog-type hull planks from the PLS94 site (Goodburn 1997a, fig.83c). The three reused ship planks found were tangentially faced and had clear marks from manual sawing surviving on them. A sloping step 8mm high on the face of the plank [84] was found in line with several saw marks. This can be identified as the 'saw kerf join scar' seen on much Roman and later medieval planking (Goodburn 1991b, 1992a:113) and characteristic of forms of trestle sawing, where the sawyers have to saw from both ends. Usually the kerfs were not perfectly in line and a small step was created, often with a small split triangle and sloping saw marks crossing over. Some experimentation has been carried out with various methods of hand rip-sawing including different methods of trestle sawing ('see-sawing' on one trestle, double trestle sawing, sawing on a tripod, and pit-sawing, Append.4). Each method produces its own set of distinctive marks. Sawing on trestles or a tripod is particularly suited to the use of a rip saw held in a frame as was used in Roman times in England and more recently elsewhere. But it is also clear that open saws were used with trestles as well (fig.85 and Goodburn 1992a:113).

The marks on the PLS94 planking were mainly at steep angles to the long axis. This is most typical of the double trestle method with the saw baulk supported horizontally which was almost certainly used in this case. In non nautical 13th century woodwork it is clear that the planks were generally sawn from square hewn baulks (Goodburn 1992a:114). If this was the case with these planks the saw-baulk would have weighed about 0.25 tonnes/m length and six or seven planks about 50mm thick could have been cut from it (fig.85c). Clearly considerably more infra-structure was required to produce hull planks this way than by cleaving with commensurate socio-economic implications (9/4/3 below).

Interestingly Lahn noted that saw marks on the 14th century Bremen cog's keel plank also ran at a slant and occasionally changed direction (Lahn 1985:53). This may indicate that some form of trestle sawing had been used in that case.

The parent log for the PLS94 planking would have to have been about 0.65-0.70m in diameter at chest height, and the parent tree of medium to fast growth and between 100-150 years old (Table 1).

Sawn elements for keel-type vessels

A small number of sawn elements also appear to have been used in the main structures of keel-type clinker hulls from the later 13th century, such as the tangential wale strake from the Kingston No3 boat (Goodburn 1991a:111, fig.86a). Here faint, but clear saw marks survived where the timber was knotty which were drawn and an impression taken. Sawing was used presumably due to the length of the timber needed of at least 6.4m probably rather more, in this case. Very recently an oak orloke repair plank from one of the slabs of planking of the TYT98 Galley was found to have clear marks of being see-sawn sometime in the late 13th century (fig.86e. Goodburn Forthcoming d). The plank when excavated was cut for reuse as c. 3m long, and was 250mm wide by 30mm thick. As the corners of the plank still had a little sapwood in places it is possible to note that the slightly crooked parent log was only about 0.4m diameter at the mid length. The parent tree was c. 100 years old, much younger than that used for the original Irish wildwood cleft boards.

Mistaken identifications of medieval sawing in nautical work

Some oak trees grow with a rather regular wavey grain often causing confusion with saw marks. Some of the radially cleft planking in the Kingston boats had ripple grain that was initially mistaken for saw marks by some archaeologists who had not taken account of the erosion of the boards.

An apparently 15th century frame fragment from the Bursledon, R. Hamble, wreck published recently (Clarke et al 1993) had very clear saw marks on the face forming perfect regular arcs indicating the use of a circular saw. Circular saws were not otherwise known until the late 18th century and not widely used until the mid 1820's or later (Edlin 1949:17, Goodburn 1993b). Thus, either the dating evidence is wrong or the timber had been resawn with an early circular saw, perhaps for making souvenirs which was a widespread 19th century practice (Goodburn 1993b).

Advantages and disadvantages of using sawn planking

The key advantage of using sawn planking in boat and ship building was that wider longer planks could be cut from smaller, knottier, probably more local and less expensive trees than ship boards. Other features of sawn planking eventually meant a saving in labour costs, eg. the greater lengths and widths available resulted in the cutting of less scarfs and lap bevels. The wider technical and economic advantages of adopting sawn planking are discussed below (Chapt.9/4).

A key disadvantage was the need for a larger labour force with a more complicated infrastructure such as, an expensive large saw, trestles etc. Another disadvantage related to the structure of oak timber in particular was that sawn timber is weaker and much more prone to distortion and shrinkage than radially cleft material. Experience shows this is particularly true of oak plank under about 50mm thick. Thin tangentially sawn green oak plank can actually be split by exposure to warm sun and wind in one day whereas, green radially cleft board will merely harden slightly in those conditions. Evidence of the splitting and distortion problem in using sawn oak plank can be seen in many ship and boat finds. For example the planking of the Bremen Cog, had already been repaired in places along splits although the vessel was not even completed (Lahn 1985:55).

EVIDENCE FOR THE EARLIEST USE OF PIT-SAWN TIMBER IN ENGLISH SHIP AND BOAT BUILDING

Diagnostic features of the pit-sawing method

The pit-sawing technique involved the sawing of timber over a shored pit in the ground or on a large raised gantry of some type. The top-sawyer was able to step off the end of the timber being sawn and thus the kerf could be made in one direction from one end to the other. Sometimes a small split triangle survives on pit-sawn faces at the end of the cut caused by the timber splitting before the saw reached it. Usually all the cuts were made to temporary support beams together, the timber being sawn was then rolled forward and the sawing began again. Detailed recording work on the City of London waterfront coupled with tree-ring dating has dated the first use of pit-sawn planks on land as c. 1420 AD at the MoLAS site MBC97 which over lapped the famous Tryg Lane excavations (Goodburn and Minkin Un Pub 1997).

Sparse early evidence

The archaeological evidence for pit-sawing in nautical work is rather sparse. However, the sawn stem timbers found at the Poole Iron Foundry site do not have saw marks that cross over each other and were thus, almost certainly pit-sawn (see above, and fig.76b). Curved timber requires careful support and fastening down for such work. The Poole Stem timbers lie within contexts finds dated to the early 15th century (Watkins 1994:10). A very small fragment of what appears to have been sawn oak clinker boat planking was also found (Allen 1994:44). This dating would broadly overlap with that recorded for the introduction of pit-sawing in waterfront carpentry in London (Goodburn and Minkin 1998).

Some early post-medieval evidence for the use of sawn timber in Carvel built craft

By the very beginning of the 16th century pit-sawn oak hull planking was clearly in use in England as shown in the main hull planking of the Mary Rose built c.1509-11 (see Append.6). The clear saw marks on the hull planking do not cross over each other and there are no saw kerf join scars, therefore the planking was pit-sawn. The ordinary hull planking varied in dimensions but was very approximately 75mm thick and between 350-450mm wide. Interestingly the lighter clinker-style planking of the castles was still radially cleft oak made in England, presumably used for weather tightness (Dobbs and Bridge 2000). The main hull planking of other wrecks of this period, Cattewater and Studland Bay (Redknap 1984:23, Hutchinson 1991:172,) also seems to have been sawn but the method used has not been investigated. It should also be noted that both vessels may have been built further south in Europe, in any case.

Evidence from fragmentary carvel vessel finds

The fragments of oak planking from a carvel built vessel of the late 15th to early 16th centuries found at Camber in E Sussex were also sawn (Goodburn 1990). Unfortunately they were too small and eroded for the method used to be reconstructed (fig.86b). However, it is clear that the planking had been sawn from relatively fast grown oaks only about 0.45m in mid length diameter. The knotty upper bole was used which could not have been cleft.

In London reused carvel ship planking of 16th century date has been found on several sites but only recognised and recorded in enough detail for use here at the Sothwark ABO92 (fig.86c). Here a group of carvel ship planks were found reused in a late 16th century dock wall. They were all tangentially, sawn and punctured by large oak treenails. It is just possible that a slight step in the face of plank [5075] was a saw kerf join scar but this could not be verified. Plank [5075] was approximately 0.45m wide far in excess of the width of the widest cleft planking of that date (Table 1).

Evidence of the recycling and re-sale of the irregular, hewn and sappy, outside slabs of pit-sawn baulks was found with shipyard debris at the Limehouse VIT96 site (8/1/2). Such timber was clearly rejected for use in the hulls of vessels built next to the site, probably because it would have been too sappy and prone to warping,.

Sawn elm plank material in 16th century Clinker built vessels

Several London excavations have yielded sections of reused, sawn clinker boat planks of 16th to early 17th century date. The examples were often found along side radially cleft oak boat boards. The list of sites includes MOR88, GandS88, ABB88, BEY95, MGS96, VIY97, and TWE98 (Goodburn 1991:111, Marsden 1996, Saxby and Goodburn 1998:190, and fig.84). Most of this material was also of a new species group the elms which can not be cleft into boards, due to its interlocked grain. None of this material has shown evidence diagnostic of any other method of conversion than pit-sawing.

In some cases narrow radially cleft oak boards have been found articulated with wider sawn elm boards (MOR88 Append.6 Goodburn 1991:111). This must have resulted in a distinctive appearance in the parent vessel. The elm planks were apparently used below the waterline as most of the elms are less durable than oak. However, they take the often extreme bends and twists found there particularly well. This practice clearly began in the 16th century in SE England (Elsden 2001).

Sawn oak planking in clinker building

The sawn oak planking also appears to have been combined with radially cleft material in at least two cases both reused in the early to mid 17th century. At MGS96 a small articulated planking section included radially cleft and sawn oak material (fig.86d). The sawn planks were 270mm to 300mm wide and had sapwood along the edges. They were clearly sawn from a fairly fast grown parent tree(s) around 0.40m in diameter whilst the 200mm wide cleft board came out of a parent tree around 0.6m diameter.

The beginnings of recent traditional southern English practice in selecting material for clinker planks?

The BEY95 articulated slab (fig.84c) included one wedge shaped board that appeared to have been radially cleft, and two planks that were clearly sawn out. One of the sawn elements was hewn to a lenticular shape, presumably so as to better match the cleft board and allow shorter lap nails to be used. What is most interesting is that the complete sawn plank had a conversion type new in the corpus of London material. It was somewhat between truly radial or tangential and clearly did not include the centre of the tree. There are two possible explanations for this. Firstly, it was sawn from a log that had been cut into four ('1/4 sawn'), a special, expensive, technique used in recent times for joinery and cabinet making as it produces very stable material. Or secondly and perhaps most likely, it had been cut from half a wide through-sawn slab as the vast majority of clinker boat planking was (and is) in recent traditional boatbuilding in southern England (fig.95a, eg. McKee 1972:7). Using this method each slab produces two planks, occasionally more, avoiding the split-prone pith. Even half a pit-sawn slab was often wider than some of the cleft boards in use at the time (Table 1).

7/6/7 RULES OF THUMB

It has long be noted that traditional boatbuilders in NW Europe have used various rules of proportion sometimes including measurement based on the lengths of body parts, and or geometry (Christensen 1985:202, McKee 1972:7, Crumlin-Pedersen 1986a:222). Space precludes any detailed consideration of these features here except to note one very clear example. In the Kingston boat finds the pattern of frame fastening indicated by the treenail pattern was repeatedly centre to centre about 0.47m or a cubit or ell (Goodburn 1991a:111). This coincides with Christensen's shorter medieval Norwegian ell (Christensen 1985:202). Other rules of thumb relate to such features as lap width and plank thickness and the proportions of scarfs (see Table 2). For example recent English clinker boat builders would often use a rule of thumb for scarf slopes of c. 1:7, although as much as 1:12 might be requested by the navy (from own observations and conversations with many boat builders in SE England , and Leather 1973:86-7).

7/6/8 METHODS OF WORKING OUT STRAKE SHAPE

The most common term in English for this practical exercise in 3D geometry is 'spiling'. It is extremely difficult, if not impossible to reconstruct exactly the methods used in early English work, and it will not be attempted in detail here. However, the recent traditional English practice of using a 'spiling batten' (thin board to bend round moulds of the desired part of hull) onto which the shape of the actual element is marked is unlikely to predate the late 16th at the earliest. A simpler method in which boards or planks are roughly shaped by an experienced eye, pre-bent and then 'offered up', held at the desired angle with the strake below, marked and trimmed to fit seems more likely. This sort of approach is still used by some traditional clinker boatbuilders in a few parts of N Europe (Gothche 1985:34, Christensen 1972:239). The reason for the adoption of a more complex approach by many English boatbuilders is probably the use of halved, wide sawn slabs (fig.95a) which could not be easily handled and the prevalence of carvel building techniques.

7/6/9 EVIDENCE FOR METHODS OF BENDING AND TWISTING PLANKS AND BOARDS

Using slightly seasoned or totally green boards or planks allows for easy accommodation of moderate bends to enable the elements to make or fit the hull shape (see above). However, very extreme bends and twists required the use of two ancient methods other than the well known steaming technique which appears to be an 18th century introduction.. These were fire-bending and hewing out of solid.

Evidence of bending with fire

In the recent Dutch practice flames are played on dampened planking held at one end over a trestle whilst the other end is weighted or twisted with a clamp-like lever ('klaas'). This results in distinct areas of charring where the bend was tightest. During a visit to the Batavia ship replica yard at Leleystad, Netherlands, charring up to 10mm deep in 110mm thick sawn oak carvel fitted planking could be seen, and a few mm of charring was visible in the oak sheer strake of the clinker built shallop towards the bow. The patches of charring on the possible sheer strake of the Kingston 1 boat are closely similar to those seen in the shallop. This is taken as evidence of fire bending by medieval English shipwrights around 1300 AD (fig.87). The 16th century hood ends from MOR88 also bore traces of charing suggesting fire bending may have been used (fig.77).

Hewing out of solid

Particularly twisted and bent boat planks, typically hood ends, are still shaped by hewing out of thick planks rather than by bending by a few Scandinavian clinker boatbuilders (eg. Gothche 1985:33). The practise of hewing these ends may perhaps have led to the use of the English term 'hood ends' for 'hewed ends'. Finding archaeological evidence for this practice in the English material has been unsuccessful so far, but it cannot be ruled out. Indeed, it may be the reason why hood end boards were often so short, as the extreme twist was only required for a short length.

7/6/10 SOME EXAMPLES OF VESSEL BOARDS AND PLANKING TABULATED BELOW

It has not been the aim of this study to provide a large catalogue of nautical timbers but an annotated list of the significant material examined for this study is supplied in Appendix 6. However, some chronologically comparative tabulation of key features of ship and boat planking considered should demonstrate the important broad trends together with the illustrated material and the discussion above (see figs.75,76,77,78,82,83,84,85,86, and 87). The key information used to compile table 1 was drawn from main publications cited elsewhere in the text or site archive records held at the Museum of London.

TABLE 1 A SUMMARY COMPARISON OF FEATURES OF HULL BOARDS AND PLANKING FROM SELECTED VESSELS C. 900-1600 AD.

Site/vess. name	No.	Conv. meth	Conv. Type	Sp.	W. mm.	T. mm.	L m.	Tree age	Date cen.	Cons. Type
Graveney	var.	C	R	O	250	25	1.5	280+	10	#Keel
bottom		C	R	O	280	37	4.5			coaster
TEX88	2719	C	R	O	275	20+	1.2+	150+	10	#Keel?
UPT90	7166	C	R	0	270	30	1.0+	220+	10	#Keel?
TEX88	2409	C	R	O	280	29	2.92+	200+	10/11	*Keel

Hedeby/1		C	R	O	250	24	5.5	300+	10	Keel
various		C	R	O	375	24	10.2			longship
Skuldelev side		C	R	O	400	25+	5.8	?200+	11	Keel
/3, bottom		C	R	O	350	30	3.5			coaster
sheer		C	T	O	420	-	10			
NFW74	var.	C	R	0	350	24	2.3+		10	*Keel
BUF90	7483	?	T	A	340	25	3.0+	200+	10	Proto
	7484	?	T	O	320	25	3.0+	200+		hulc
UPT90	7248	C	R	O	230+	25	2.52+	200+	10	*Keel?
BIG82	6697	C	R	O	324	20	0.5+	c350	10	*?
BUF90	8105	C	R	O	200+	25	2.44+	c200	11	longship?
Utrecht 1	var.	?	T	O	c500	30	9.0	-	?11	?Hulc
Customs	-	C	R	O	230	20	-	280+	12	Keel
house/1		C	R	O	270	32	-			
bottom										
Dublin	var.	C	R	O	320	45	c3.4	?	12	Keel
TG6		C	R	O	300	28	c3.4?	?		
Kollerup	var.	C	T	O	c500	-	4-8m	?	12	Cog
PLS94	84	S	T	O	360	50	-	c150	13	Cog

TYT98 704 C? T B 300 45 5.2+ c200 13 Galley
710 S T O 220 30 3.0+ c100 repair
705 C R O 230 45 2.6 c. 250.
706 C R O 280 30 1.7 c 90 repair
HOR86/1 445 C R O 285 30 2.98 c150 14 Keel
upper/side447 C R O 220 30 2.90+ ?
454 C R O 270 30 2.73
bottom 509 C R O 220 30 2.5
510 C R O 230 30 3.52 c100
512 C R O 250 30 2.50+

HOR86/2 907 C R O 220 45+ 3.06 c150 14 Keel
bottom 910 S? T O 230 45 3.88 repair?

HOR86/3 884 C R O 200 50 2.15 14 Keel?
bottom 880 S T O 220 75 5.76+ Meginhufr.?

Blackfriars C R O 230 35 - ? 14 Keel
/3-various C R O 270 35 - 150

SYM88/ - C R O 310 60 3.30+ 350+ 14 Keel?
Baltic

Bremen cog. . S T O 500c40 4.5 140 14 Cog
side S T O 500c40 8.0
bottom S T O 400 50 4.8

ABO92 5126 S T O 420 60 2.08+ c150 16 ?
ship lap.

MGS96311 C R O 180 30 2.35 c120 16 Keel?
312 C R O 200 30 2.35

VIY9 408	S	T	E	330	37	0.94+	c.100	16	Keel?
MGS96308	S	T	E	350	35	2.45+	c.100	16	Keel?
MOR88 32	S	T	E	350	35	2.9+	c.100	16	Keel?
JAC96 301	C	R	O	150	35	1.80	c.170	16	Keel?
BTH88 636	C	R	O	152	27	2.10	c.160	16	Keel?
Camber var.	S	T	O	320	70	2.00+	<100	?15-16	Carv.
Mary Rose main hull	S	T	O	c400	c75	c8.00	<200	16	Carv. warship
ABO925074	S	T	O	230	70	2.4+	<150	16	Carv.

Notes for table 1

A = Ash , B = Beech, E = Elm, O= oak

* Denotes New Fresh Wharf style fastenings, # denotes Graveney style fastenings. Hood ends, short repair planks and broken elements have been deliberately excluded where that has been possible.

7/6/11 SCARFING BOARDS AND PLANKS IN CLINKER WORK c.900-1600AD.

Some attention has been paid recently to the issue of changes in end to end or 'scarf' joints used in clinker vessel building (McGrail 1993:43, Bill 1995:43). It is quite clear that there was variation through time and from shipwright to shipwright and that different levels of skill and time were applied to cut the various forms (Goodburn 1991:111). The form and proportions of the scarfs used in selected finds from the London region are summarised diagrammatically in Table 2.

The development based on current evidence can be summarised as follows;

1/ Pre-Conquest period scarfs were short and through-splayed in the Graveney and Scandinavian style finds, with typical thickness to scarf length ratios of about 1:3-1:5. However, in some of the London finds the scarfs were much longer such as in NFW74 with thickness to length ratios of about 1:7.5. There appears to have been no clear distinction between those used in vessels with Graveney or NFW74 style fastenings.

2/ During the 12th century ratios of c. 1:8 were used as in the Customs House vessel, and they often had slightly protuberant ends outboard (Marsden 1996:44).

3/ By about 1300 even longer scarfs were used consistently with ratios of c. 1:9-1:10 in Kingston 1, the stopped splayed or nibbed type was also sometimes used. Often two types of board scarf have been found used in the same vessel; perhaps one by the original builders and another during repairs? (eg. Kingston 1 Goodburn 1991:109, or Blackfriars 3 Marsden 1996:68).

Both the partly proud long and short through-splayed types have been made with axes for reconstructed vessels in Denmark and the later found most difficult to make well (J. Bill Pers Com.). The longer, later, Danish examples were seen as comparatively crude, well stuffed with luting in practice. However, the longer nibbed type used in the original work in Kingston 1 were exquisitely fashioned and would have required more time and skill to make than the other two forms.

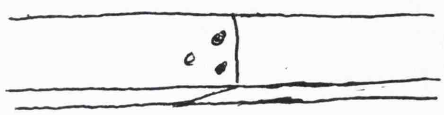
All these early scarfs were luted (see below) and fastened with shorter versions of the lap fastenings. Repairs to treenail fastened examples often involved Graveney style rivets or small iron nails hooked over.

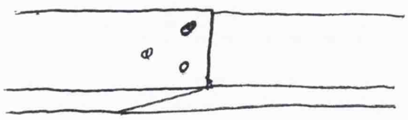
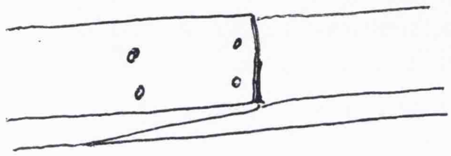
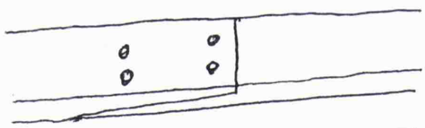
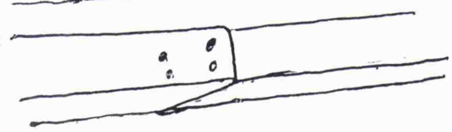
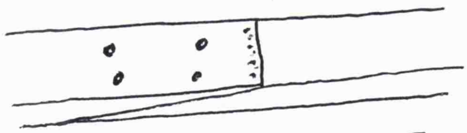
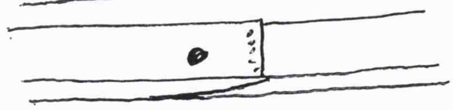
4/ In the 16th century work a new feature appeared which was the use of tacks to secure the thin ends of scarfs which were sometimes prone to warping. The scarfs used in the sawn elm planking were lengthened further with a typical ration of 1:12 and often left with slightly thick, proud ends (eg. MORR88 [34], or VIY97 [408], fig.84a). Those used in the contemporary more stable, radially cleft oak planking were shorter with ratios of 1:5-1:6.8 (Table 2).

EVIDENCE FOR HOW WERE THEY CUT

Where the tool marks in the better preserved scarf joints have been investigated they always appear to have been made by edge tools used at between 90 to about 45 degrees to the long axis of the timber. The earlier examples were clearly made with axes, such as in board [509] Kingston 1 where an axe with a blade over 150mm was used (fig.83b). By the 16th century the tool marks that have been recorded indicate the use of a narrower bladed axe or possible a small adze (fig. 84b). With an axe or adze the slightly concave faces required for close fitting and watertightness are relatively easily made, with a practised hand .

TABLE 2, A REPRESENTATIVE SAMPLE OF CLINKER PLANK SCARF TYPES, 10TH TO 16TH CENTURIES

Site	Timber	Scarf length	Plank thick	Ratio	Date cent.	Form
VRY89*	5715	150	25	1:6	10	
Graveney #	Av.	110	25-30	1:3.5	10	"
NFW74*	Av.	180	c.25	1:7.5	10	"
TEX88#	2445	150	30	1:5	10	"

TEX88*	2438	120	25	1:4.8	10	
UPT90#	7314	180	30	1:6	10	
VRY89~	5485	120	25	1:4.7	11	"
Dublin TG 10	Av.	70	15-20	1:3.5	11	"
CUS73	Av.	c.200	c.25	1:8	12	
Dublin TG 3	Av.	280-300	30+	1:10	13	"
Blackfrs. No. 3.	Av.	300-380	30-35	1:10	14	"
ABO92	5304	300	50	1:6	?14	"
HOR88 No.1	Av.	300	30	1:10	14	
HOR88 No.3	Av.	c.200	50	1:4	14	
MOR88 elm	034/27	420	35	1:12	16	
MGS96	311	230	35	1:6.8	16	
JAC96	302	200	35	1:6	16	"

Notes for Table 2 Dimensions in mm.

Inboard face of scarf shown top in diagram, ? denotes unknown orientation. Scarfs were almost always cut in original work to open aft to reduce ingress of water. Plank thickness is the maximum recorded where least eroded. # denotes Graveney style fastenings, * NFW74 style, ~ 'Scandinavian' style. All planking radially cleft oak unless stated otherwise.

7/7 END NOTES TO CHAPTER 7

The character of the surviving, generally fragmentary evidence used for this part of the study limits the possibilities of discussion of other important features of planked vessel construction in medieval England such as framing systems used. However, notes on that subject and others are contained in the appendices listed below and held in the back of volume 2. These appendices will be drawn on to some extent for the concluding chapter 9. Please also note that figure 92 acts as a visual summary of the main types of fastenings found in nautical timbers examined for this study.

List of appendices bearing on aspects of planked vessel construction not covered above.

Appendix 9) BRIEF SUMMARY OF EVIDENCE FOR THE CHANGING STYLES OF LAP FASTENINGS USED IN CLINKER BUILT VESSELS FOUND IN ENGLAND, C.900 TO 1600AD.

Appendix 10) SUMMARY OF EVIDENCE FOR FRAMING TYPES AND FRAME FASTENINGS USED IN VESSELS BUILT IN ENGLAND C.900-1600AD.

Appendix 11) SUMMARY OF EVIDENCE FOR CHANGES IN SEAM AND LAP WATERPROOFING METHODS USED IN VESSELS FOUND IN ENGLAND C. 900 TO 1600.

Appendix 12) SUMMARY OF EVIDENCE FOR THE USE OF SURFACE TREATMENTS IN PLANKED VESSELS BUILT IN ENGLAND C.AD800 TO 1600.

8/ SOME OTHER SOURCES OF EVIDENCE FOR MEDIEVAL ENGLISH SHIP AND BOAT BUILDING PRACTICE

8/1 THE UTILITY OF THE DOCUMENTARY RECORDS AND THEIR NATURE

Although a variety of English medieval documentary sources include mention of vessels, shipwrights, and occasionally building operations (Friel 1995) they are often too ambiguous and lacking in detail to be very useful here. It should also be noted that there are no clear references to dugout boats, which therefore remain outside recorded history. However, there are a few moderately detailed expenditure accounts for 23 medium sized to large vessels for the period 1294-1497 in addition to many other summary accounts and accounts of repairs (Friel 1995:16). Clearly all these sources can not be reviewed here, but some examples of the potential usefulness of this type of evidence to greatly extend what we know from archaeological material is demonstrated.

Principal amongst the building expenditure lists are those of the nation wide clinker galley building campaign in the 1294-6 (Whitwell and Johnson 1926, Johnson 1927, Friel 1986, and 1995). Other sources include the 14th century Bridge House accounts for London which deal with building and repairing clinker built river craft some of which were clearly 'shoutes' probably resembling the Blackfriars 3 vessel (Dyson 1996 and Spencer 1996). These sources have been excerpted and published in various ways translated into modern English or left largely in the original medieval Latin, French and Middle English.

We are now able to interrogate such sources from three angles little used or entirely ignored by the early commentators. The first is from the archaeological perspective drawing upon archaeological work of the last 40 years. The second is from the perspective of the ethnography of traditional boatbuilding and associated English dialect terms (eg McKee 1978, 1983, Osler 1983 and the writers own contacts and experience over 30 years in the traditional boat world). This approach is particularly useful in identifying items specified in some accounts as many of the nouns are English or English 'latinized'. The third is to use insights gained from high quality experiments in early boat and ship building (eg. Bill and Johansson 1987, Andersen et al. 1997, and work done for or peripheral to this study, Append 4.)

The documentary sources in turn provide evidence of many features of craft practice which are difficult or impossible to explore through the archaeological material alone. These include aspects of work organisation, both at the building site and in the ancillary trades, the varied origins and comparative costs of materials and labour and the status of different parts of the work force. For example, it appears that during the 1294-6 galley building campaign the cost of a shipwright's labour for a day and a 12' cleft oak board were about the same (derived from average figures cited in Carr Laughton 1957:248 and Friel 1986:243). The impetus to reuse this material for nautical and non nautical purposes is clear.

The limitations of the texts are variable, some appear to list most of the materials and labour employed, such as the account for galley building in London for 1294-5 (Johnson 1927), whilst others clearly list only those bought in to supplement materials in stock (eg. Spencer 1996:209 excerpts of the London Bridge House Accounts). The descriptions of materials are also generally rather incomplete, for example the nominal lengths of boards may be noted but not the average width or thickness. A clear problem concerning the records of labour are that apprentices or casual helpers may not always be listed or paid directly by the body recording the accounts. It is uncertain weather a shipwright's most junior apprentices or 'servants' would always have been noted in the accounts.

Later medieval trading structures, such as brotherhoods of international merchants (eg. the Hansa) and scattered patterns of feudal land holdings sometimes resulted in complex, long distance, transport of boat or ship building materials. Thus, even the named location of purchase of a raw material may disguise its original provenance as it may have already have travelled some distance. Some of this long distance trade can now be tracked archaeologically especially by using such techniques as tree-ring analysis to source timber and boards (eg. Tyers 1996:196)

In short, the expenditure lists should not be seen as carefully measured accounts of all materials and labour but as somewhat idiosyncratic summaries requiring critical comparison with other types of evidence to be understood. The brief discussion here is principally concerned with the later medieval to 16th century period as details are so sparse in earlier sources.

8/1/1 INFORMATION ON CRAFT ORGANISATION IN PLANKED VESSEL CONSTRUCTION AND WORK SITE LOCATION C. 1290'S TO C. 1550

Evidence for essential ancillary work

Logistical considerations, principally the moving of heavy materials (Appends. 3, 4) suggest that considerable amounts of work took place away from the building yard. Operations such as, the selection and felling of trees, the roughing-out of structural timbers such as, framing, keels and cleft shipboards, or the gathering of luting materials are rarely described in the medieval expenditure lists. However, some notable exceptions are discussed below.

The tree fellers

Those that felled timber for vessels were often called 'carpenters' rather than shipwrights (eg. Friel 1986:42). The skills needed for felling, bucking, loping and hewing timber were fairly widespread. Much of the roughing-out work may therefore have been carried out by carpenters working to master shipwrights instructions, not by the shipwrights themselves by the 13th century, although this may not have been the case earlier. However, it was probable that the shipwrights had to provide close instruction when some of the more complex curved elements were required that were not used in land carpentry. We might also suspect that for smaller projects in areas with plentiful supplies of timber the ship or boat yard workers might also have been more involved in timber felling and roughing out. That the documents that survive do not show this pattern may reflect the urban location of the vast majority of the projects mentioned.

Some light on the work of woodsmen and clovyers- the board makers

With the exception of a brief reference in the account for the Ipswich Galley of 1295 (Friel 1995:17) there is little suggestion of shipwrights making their own cleft shipboard. Indeed, the accounts repeatedly describe boards being bought from merchants at scattered locations typically well inland and or at port towns (fig.88). It is clear that some vessels were built with boards from varied sources in England or even a mixture of English and SE Baltic 'Estlond board' (Friel 1995:17). Archaeological evidence of this practice was recently found at the TUR95 site, Turks Boat Yard Kingston Upon Thames. The 'Turks' concerned by chance being part of a long line of shipwrights and boatbuilders known from medieval times on the Thames. A small section of reused, scarfed, radially cleft, oak clinker planking was found and tree-ring dated to the 13th century. One board matched the London region curve best, and the other the Bristol curve (Tyers Pers Com.). There was no obvious evidence of repair. Similar evidence of mixed origins for boards was found recently in a slab of reused later medieval shipboards found at the well known site of Coppergate in York (Goodburn 2000b). Their slow grown imported SE Baltic boards were used with fast grown probably local boards. The shipwrights working on boats used for work on London bridge in the late 14th century, appear to have used shipboard bought in London on the one hand and of specified rural origin at Croydon on the other (Spencer 1996:210, fig.88).

Revising some earlier interpretations of the Galley accounts

Sometimes early 20th century understandings of aspects of the materials lists for these large projects can now be rejected whilst others are borne out by recent archaeological findings. An example of the former is the suggestion by Whitwell and Johnson that references to boards of 'Elne' in the Newcasle Galley account for 1294-5, show that some elm boards were used in her construction (Whitwell and Johnson 1926:164). Elm was in common use in traditional boat and ship building in early 20th century Britain and so their interpretation of 'elne' as meaning elm is understandable. However, we can now show, after the accretion of much archaeological information on the materials used by shipbuilders at this time in N and NW Europe, that the term must have referred to a place of origin for the timber rather than species. Indeed, it seems that 'Elne' almost certainly stands for a corruption of 'Eldena' which was a medieval port on the NE German coast near Stralsund (J. Meyer Pers Com.). Other timber used by the Newcastle galley builders was bought from 'Geraddo de Strallesunde' ie a merchant from that area.

A few important documentary sources give useful insights into the making of shipboard in England, and some idea of its common dimensions. In 1404-6 the Abbot of St Albans gave 40 oaks to the king and they were converted, where they were felled, into 1,200 boards of unspecified dimensions. In the same year the Abbot of Waltham gave 10 oaks made into 390, probably rather larger, boards (Carr Laughton 1957:247). In the first case each tree produced about 30 boards, in the second about 39. This is in broad agreement with the experimental data suggesting that given large, straight-grained butt logs, up to about 32 medieval ship boards could be produced (7/6/4, Append 4.). In the case of a few particularly large, straight, knot-free, boles more than one board-quality log might be obtained, possibly explaining an average of 39 boards in the second case above. The craftsmen who produced these boards were called 'clovyers' and produced between about 10-12 a day (Carr-Laughton 1957:248). Experimental work (Vadstrup 1997:89, Append.4) shows that, even given perfect timber it would not be physically possible to produce that many fully finished boards even in a long summers day. The implication is that the boards were only rather roughly trimmed with much of the surface left 'as-cleft' and that they were probably relatively short (fig.89).

8/1/2 WORK ORGANISATION AT THE BUILDING YARD

Friel has examined this issue principally in relation to the 1290's Galley building accounts, and described the roles of some shipyard-based craftsmen, dividing them into four groups sometimes under the loose supervision of one named master, but often not (Friel 1986:41). His four principal categories of workers, starting with the most senior were, the master shipwrights, followed by 'berders' (=boarders, journeyman shipwrights?), the clenchers (those who rivetted the numerous rove nails) and 'At the bottom were the holders ..' ('hoyllers'in the original texts). The holders, were those who supported the rove nail heads during clenching.

However, in his discussion of the Galley account for Lyme, Dorset, Friel actually lists 16 distinct groups of craftsmen and labourers, from the master shipwrights through carpenters and sawyers to boy watchkeepers and men who dug the launching channel (Friel 1986). But even this list his does not include certain essential workers such as a carter to move the locally felled timber to the building site, or any clovyers. Table 5 attempts to graphically summarise the c. 25 different categories of craftsmen and labourers that probably worked on the building of large English clinker built ships in the later medieval period. A total of between about 30-40 men appear to have worked at the Lyme Galley yard (Friel 1986:42). In fact up to 50 men are sometimes noted as employed in such a yard (Tinniswood 1949:281)

Table 5. The work force organisation required for building a large high medieval clinker built ship, based primarily, on a critical re-interpretation of the Lyme Galley building account of 1294 first summarised by Friel (1986).

Worker(s)	Notes	pay d/day
optional? senior shipwright	-for London works	
4 master shipwrights		5-51/4
3 berders (at least)		4
5 carpenters	felling and hewing timber	4

6 clenchers	clenching rove nails	3
6 holders	supporting rove nail heads	2
1 man	boring and driving treenails	2
(in practice 2 people would have been involved in this 1 inboard and one outboard)		
1 man	making breast works	2
1 treenail maker		11/2
2 Sawyers		piece work
1 smith		"
porters		"
1 man tallowing hull		"
1 boy collecting moss		?
1 boy heating pitch etc		?
1 boy acting as watchman		?
labourers	digging launch trench	piece work

'Hidden' labour not
listed by Friel

Carters	to move timber	"
Clovyers	to rough-out boards	"
Women?	preparing luting in some cases	"
Tar-oil makers		"
Specialist merchants of materials		"
Watermen-Seamen	to move materials	?
Iron smelters	to make raw iron	?
Wood colliers	to make charcoal for iron	?

Clearly table 5 is not a complete list but begins to show just how many people were associated with any large medieval shipbuilding project. This figure may well have been well in excess of 100, not even including, those involved with the rigging and sails (which are not covered in this study).

A contrast is provided by the 14th century expenditure lists for work on the much smaller boats and barges for London bridge (Spencer 1996), where it is recorded that the yard work was limited to two or three categories of craftsmen mainly referred to as 'shipwrights'. The vessels worked on here appear to have been similar to the clinker built 'shoute' (river barge) Blackfriars 3 (Marsden 1996:55), with an average of about four men working at the same time on new vessels. That is four men were documented as having been paid directly but it is possible that there were others who were 'servants' of these men.

Hints of the contribution of women

Perceptive work by Walton has discovered a correlation between the names of shipwrights building the Newcastle Galley and the names of women supplying luting materials (Walton 1988). The women may well have been the shipwrights wives. This is quite plausible where animal hair was the material used particularly wool, as the roughly prepared rolls of wool for spinning called 'rolag' are identical to those used for luting in many clinker vessels of the high medieval period. Sometimes women servants of the shipwrights are also mentioned in the galley building accounts for 1294-5, as at Newcastle where the men had a paid 'girl servant' for a period (Whitwell and Johnson 1926:157).

8/1/3 A NOTE ON REFERENCES TO CAULKERS IN MEDIEVAL ACCOUNTS

Strangely the absence of 'caulkers' as a craft category in accounts prior to the mid 14th century has not been seen as significant. It has been suggested simply that shipwrights did the work (Friel 1995:64). An explanation that would better fit the material evidence, is that the term was not used because the practice was rare in England before the mid 14th century. Medieval clinker vessels built in the 'keel' tradition were 'luted' as building progressed not 'caulked' after the hull was finished, except at crudely made overlapping scarfs, or in some repairs. When the term is used coherently it is in connection with named cogs (Friel 1995:64) which are shown by archaeological finds, such as the late 14th century Bremen Cog, to have been caulked after assembly in a distinctive style (Ellmers 1985:60). Later, carvel built vessels, built with wide tangentially sawn planks, which are prone to considerable shrinkage, also had to be very extensively caulked to float at all eg. the Mary Rose. It was necessary to do this work at regular intervals. Caulking as a specialist craft appears to have been associated with cog and carvel vessel building. It may well have been associated with the introduction of the watertight deck at some point in the 15th century in England.

8/1/4 INFRASTRUCTURE MENTIONED IN THE ACCOUNTS

The primary edge tools used by shipwrights and ancillary workers are not mentioned in the historical sources and must be reconstructed from toolmarks, iconography and tool finds. However, some of the building aids and essential infrastructure particular to large scale projects are mentioned. In any form of planked vessel construction a considerable number of temporary supports are needed before the whole structure is joined together, and a scaffold for access for larger craft. Building accounts sometimes record the purchase of large numbers of cheap poles eg. '...32 spars of alder..' used for the Lyme Galley building (Friel 1986:42). These must have been used for temporary supports and possibly a scaffold for access. Small nail holes can be seen in the stems of the Graveney, and Blackfriars 3 vessels (figs.74,76.), and in the top of the used stem from Poole, which appear indicate the temporary attachment of such shores. These would have held the stems steady during the building of the vessel.

Shipbuilding materials were valuable and protected, the galley accounts often mention, fences and store buildings as well as watch keepers. For example, the London Galley building site (in the vicinity of 'Galley Quay' City of London) was fenced with new posts and rails and pales made from old cask staves (Johnson 1927:425). Sometimes earth cut 'doks' were noted for building large vessels so they might be floated out (Friel 1995:55.). In other cases launching arrangements were apparently more ad hoc, involving dug channels, and or temporary ways.

8/1/5 MATERIALS MENTIONED IN THE ACCOUNTS

The key materials of most direct relevance to this study mentioned in the accounts are different forms of timber, board and plank.

'Merimium' or timber

It is clear from summarised documentary sources (eg. Friel 1986:42, 1995) and some tree-ring studies (eg. Nayling 1998) that structural timbers such as the backbone assembly, framing timbers, knees and cross beams were generally felled and roughed out shortly before building programmes began. That is, they were fairly or entirely green. This is also corroborated by the crispness of toolmarks and good condition of sapwood on many well preserved ship timbers. The boards, being timber of thin cross section and generally bought in, will have been slightly more seasoned in many cases.

Large timbers such as keels and keelsons, might be subsumed under descriptions such as 'great timbers' as for the Lyme Galley account or specifically identified, as in the second London Galley account (Friel 1986, Johnson 1927). Smaller timbers for repetitive items such as frame elements and cross beams were generally dealt with in bulk. For example the '...foteken, wrongen et schebbemes..' supplied by one Alexandro ate Walle for the second London Galley (Johnson 1927:431).

Some of the larger timber referred to must have been sawn into long timbers such as wales, or long hull planks known in cog and carvel building styles, and in later keels for special purposes (Chapt.7/6/6, Goodburn Forthcoming d and entry for TYT98, in Append. 6). An interesting reference in the Bridge House accounts for 1382 clearly refers to making two stems for a new boat out of one curved timber, which was almost certainly achieved by sawing a hewn timber in half longitudinally (Spencer 1996:209).

'Bords', 'shipboard' or 'clove board'

The archaeological evidence shows the vast bulk of the hull envelope of English clinker built vessels were of cleft oak boards until perhaps the mid 16th century (see 7/6). The building accounts often specify particular lengths of these boards suggesting that there were more or less standardized sizes between about six and eighteen feet (1.84-5.49m, Table.6). However, the width and thickness are not specified indeed it is unlikely that the lengths were very closely observed as they do not appear to have been neatly sawn across, but roughly axe cut (fig.89). One of the most common sizes in the 1290's Galley building accounts seems to have been 12' (c. 3.66m) and this is approximately the length of the longest boards surviving in the broadly contemporary Kingston 1 boat of c. 1300. Certainly some degree of standardisation would have made trading in the material far easier.

Long boards and higher prices

The longer boards are consistently noted as disproportionately very much more expensive than shorter boards, eg. in the Lyme Galley account the 12' boards were almost four times the price of the 6' and the 18' were 10 times more expensive. It has been suggested that either the scantling was also greatly changed or the longer boards might have been sawn-out (Carr Laughton 1957:248). As sawing planks required more workers, more tools, trestles and infrastructure than cleaving boards this might make logical sense. The clear use of a see-sawn oak plank for and orloke strake repair in the TYT98 clinker galley type vessel may be an example of such a board (7/6/6).

An other possible explanation, based on the archaeological evidence from England and insights from experimental work is that once the tall 'wildwood' oaks were gone by about 1250AD in England finding straight grained, fairly knot-free logs much over 3-4m long was more and more difficult. Even today in England good quality sawn oak planks over 12' long are considered over-sized and are usually sold at a premium. It also requires more skill to cleave longer boards evenly. These would have been the predominant factors in the greater cost of the boards over perhaps 8' long by the later medieval period.

Table 6. Ship board lengths for use in hull skins noted in some English medieval expenditure accounts, taken from Friel 1986 (*), and Carr-Laughton 1957 (#).

Lengths Ft.	m.	Date of reference	Source	Cost/board/d
6	1.82	1294	*	<1
8	2.44	"	*	2
12	3.66	"	*	51/2
12	"	"	#	4
14	4.27	"	#	9
18	5.49	"	*	101/2

Notes. 1) The species of the boards was rarely noted, but archaeological finds suggest that it would almost always have been one of the oaks. 2) Archaeological evidence also suggests that 10'(3.05m) cleft boards were also produced in quantity, and by later medieval times that boards (or 'planks') over 12' would probably have been sawn in England (see 7/6/6). This might be indicated by the large increase in price between the 12 and 14' categories?

8/1/6 NOTES ON FASTENINGS AND THEIR MAKING DERIVED FROM THE BUILDING ACOUNTS

Other materials mentioned in detail include fastenings. Various forms of iron nails and treenails, and also surface treatments such as tars, oils, fats and paints are mentioned in many of the accounts. Additional information on these aspects can be found in appendices 9, 11, and 12, but two key points concerning treenail making are noted here. In the London galley accounts treenails are referred to either in the Latin or English (eg. 'clavis ligneis', or 'Wythewenail'). The term 'Wythewenail', probably implying the use of willow which can be correlated with the species identifications of most excavated medieval treenails of 'willow or poplar' (eg. Tyers 1994b:209). Thus, we may consider that the examined treenails are of almost certainly willow rather than poplar.

The subtle evidence provided by some of the building accounts can be shown by the following. The London Galley accounts make clear that several different people were involved in the production and fitting of treenails. Willows were felled, and billets ('Bileth') cut and split away from the shipyard near Greenwich. The treenails were then carved from the billets on one side of the City of London and finally then transported and to the Galley yard where they were sold to the shipwrights (Johnson 1927:432). The shipwrights did not make their own, but bought them in bulk for large projects, probably trimming them just prior to fitting and after a period of drying. The humble galley treenail had thus passed through at least 5 hands before being driven home and wedged!

8/1/7 PROVENANCE AND TRANSPORT OF MATERIALS MENTIONED IN THE ACCOUNTS

It is clear that fairly local sources were preferred for the structural timbers, straight and curved, used in medieval English planked vessel building. Often shipwrights travelled to felling sites to select trees or partly prepared timbers, eg. John Forster, who spent a day travelling to and from Bekenham Park to view timber and 'wrongs' in 1461 (Marsden 1996:93). Figure 88 provides a graphic summary of selected documented sources for timbers and boards gleaned from several expenditure lists for work in the London region. It clearly presents a rather fragmentary view of this specialised aspect of medieval timber supply. However, it does indicate how shipbuilding projects often drew timber from several disparate sources with in a landscape mosaic. Curved timbers are, in practice, much harder to move than the equivalent weight of straight baulks or boards, some of which were imported from as far as the SE, Baltic region, Germany or Ireland (Whitwell and Johnson 1926, Salzman 1952:245, Tyers 1996b:196, 1999 Un Pub.).

Very large ship timbers posed particular transport problems. For example, it required the use of a six horse team and cart to haul the mast step timber of the second London galley from Addington, Surrey to central London (Johnson 1927:426). Presumably this timber had to be roughed out where it was felled but it would still have been massive.

8/1/8 TIME SCALES OF BUILDING AND ORDER OF CONSTRUCTION

Expenditure accounts do not record the total time it took to build a vessel from scratch ie trees, buried iron ore and sheep. However, they sometimes provide a very rough figure for the man/days it took for the work in the shipyard. For example, the 1290's Galley building accounts vary between about 2000 man/days for the comparatively small Lyme Galley to about 4,120 for the much larger Southampton example (Friel 1986:42). To this we might add the time taken to make the bought-in materials, treenails, numerous iron fastenings, luting, surface treatments and boards etc. An all encompassing minimum estimate might be well in excess of 3,000 man (person) days for a vessel such as the Lyme galley.

By contrast the Bridge House (London) accounts (Spencer 1996) give us some idea of the time taken for the yard based work of building a medium sized, clinker river vessel probably rather like the Blackfriars 3 'shoute'. In 1382 a four shipwright team took about 144 man-days to build the basic hull. If we add the time taken to make the bought in and stored materials this figure would easily exceed 200/man days.

8/2 EXCAVATIONS OF MEDIEVAL SHIPYARD SITES

This discussion will focus on a few selected sites, particularly those which fill out the picture gained through study of finished nautical timbers for larger craft (Chapt.7) and the sources outlined above.

8/2/1 SOME CONTINENTAL EVIDENCE

Several sites in Northern Europe have been excavated which had clear evidence of boat or ship building or repair taking place on, or very close by, them. Selected contrasting examples are briefly listed here roughly in order of the volume of material excavated:

a/ Fribrodre, Falster, Denmark this large site of the later 11th century appears to have been a rural coastal settlement largely devoted to the repair and building of clinker planked vessels with both iron and treenail fastened laps. The distinctive debris layer found includes; wood chips, roughed-out treenails, wooden mauls and wedges, used frame timbers and fittings, and small fragments of shipboard of oak and beech (Skamby Madsen 1991, Append. 6). A small wattle lined inlet (slip?) was also found. This site is clearly an important shipyard excavation for the earlier medieval period, in Northern Europe.

b/ In one quarter of early medieval Wolin, Poland, treenails, rove nails, wood chips, and a few fragments of used shipboards and framing were found adjacent to dwellings from the late to 10th-11th centuries. A possible slip and capstan base were also found (Filipowiak 1981:63). Here the context of the shipbuilding, breaking and, or repair work was clearly urban and estuarine.

c/ Excavations in medieval urban land-fill deposits at Bryggen, Norway have yielded a small number of items indicative of clinker planked boatbuilding, breaking and repair close by. These include, numerous second hand nautical timbers and parts of typical clinker builders clamps or 'nippers', and a large roughed out knee (Christensen 1985:257).

8/2/2 SOME MEDIEVAL AND 16TH CENTURY ENGLISH EVIDENCE

An outline discussion of the evidence will be presented here, as much of it is published in detail elsewhere. A range of site types have been found in England which are listed briefly below:

a/ Poole Iron Foundry - Perhaps the largest and most important published excavation is that of the early 15th century Poole Foundry site, Poole, Dorset, (Allen Un Pub 1994, Watkins 1994). The systematic recording work shows that the site may be described as an abandoned, boatyard timber store, including second-hand and roughed-out new, straight and curved timbers of oak and elm (fig.90). All the timbers were of modest proportions destined for use in boats rather than ships, and lay in groups on the tidal strand. Most of this roughing-out was achieved by hewing with axes, but curved slabs for stem timbers had been divided by pit sawing (see 7/5/4). The degree of trimming of the rough-outs varied but most timbers could be described as roughly squared, and left a little over length, although a few were very waney. It would appear that the aim of the roughing out was to remove any branches, cut roughly to length, and straighten and flatten the timbers in the 'sided' plane.

The reason for storing the timber within the tidal range must have been to prevent seasoning damage such as excessive splitting and to keep it soft, some preservative function with salt penetration may also have been desired. A great problem with this practice in a sandy location is that sand on the timber will damage and blunt the shipwrights tools requiring laborious, careful washing of the timber. Some unwanted bark and sapwood was also removed presumably to reduce weight in transit. A rather dramatic event must have caused the abandonment of this useful material such as a death of the yard proprietor?

b/ Kingston Bridge- Archaeological evidence of boatyard work, dating to c.1350 AD, has been found just upstream of the bridge at Kingston upon Thames, on sites HOR86 and KIB97 (Append. 6). Some diagnostic material is illustrated in figure 89. It principally comprised three roughed-out oak knees, a slightly trimmed oak log for a futtock, several cleft oak board offcuts and the proximity of many second-hand ship and boat timbers (Goodburn 1991:108, Potter 1991:142).

The knees were fairly carefully axe hewn to square cross sections. One showed an auger mark, this probably indicates they were almost ready for use. The short curved log (fig.89,d.) was of exactly the right proportions for making a typical futtock for the Blackfriars 3 vessel. The wide, roughed-out radially cleft oak board offcut [80] was found used next to the above in a low timber river wall. The knees were found nested together apparently inside a wattle pen on the foreshore, a few metres down stream. This evidence clearly indicates the proximity of a boat or ship building, repair and breaking site close by. This site lay on the up river waterfront of a medium sized river port and bridging point on the Thames.

c) Newcastle Quay side- Scattered evidence in the form of treenails, rove nails, luting materials in quantity, small board fragments and wood chips were found during excavations on Newcastle's medieval quayside (O'Brien et al 1988). Again the proximity of a boat or shipyard is indicated, although the full significance of the material was not acknowledged by the authors. Only the luting and cordage material was studied in significant detail (Walton 1988).

d) Victoria Wharf Limehouse- The recent excavation of a waterfront site of the 1580's at VIT96, Limehouse, London produced clear evidence of carvel shipbuilding activity on the adjacent land. This probably derived from the historically known yard just to the east (Goodburn Forthcoming b, Append6.). The evidence comprised large quantities of prepared caulking materials, wood chips of oak, elm and softwood, iron fastening rejects, used and roughed-out oak cylindrical treenails and treenail offcuts, oak scaffold posts and waney pit sawn oak planks that had apparently been used as scaffold boards. Large naval craft are known to have been built in limehouse at the beginning of the 1580's. Very limited evidence of clinker boat building was found in the form of a few iron rove nails, which could also have derived from the clinker style boarding of a typical carvel ships upper works in any case. This area has become known as London's pirate quarter where many exotic items have been found on very recent excavations, having a derivation in the Caribbean or far east.

e) Smallhythe- Building docks: a few late medieval earthworks survive today in Southern England in areas known for shipbuilding which appear to be the remains of building 'doks' (Hutchinson 1994:24, Friel 1995, Fig. 3.9). But none have been subject to large scale systematic excavation, although limited trial work and associated surveying was carried out in 1998 at Smallhythe, Kent (Channel 4 TVs, Time Team, Milne et al. In Prep.). This limited work revealed clinker nail clenching debris (cut off rove nail tips), unused roves, used boat and ship rove nails and a split section of oak clinker ship frame from a foreshore deposit. In general the material suggests that ship and boat building activity took place on a large scale in the area but precise activity areas have not yet been pin pointed (Appends.6,9). The existence of a very unusual (for England) early brick built chapel with Hansa type stepped gables and some historical evidence suggests some of the inhabitants hailed from Flanders and beyond. The current view is that the building work took place on the foreshore either side of the current road through the hamlet. The area suffered intense silting up which forced its abandonment by the 16th century for building large vessels.

Two other areas two the south in the region have also provided evidence medieval clinker ship and boat building or breaking and repair. So far these include used ship rove nails from Playden near Rye, and a selection of rove nails, unused roves and cut off nail tips from a very recently excavated site in New Romney (Both sets of material were rapidly viewed by this author). .

This whole region has been well supplied with local timber and iron from the Roman period and is currently undergoing increasing survey work in an attempt to locate other shipbuilding and port sites known to have existed in the general region (H. Clarke and G. Milne Pers Com.).

f) The City of London- Nautical debris in the form of disarticulated ship and boat timbers, fastenings, some of which are distorted, and waterproofing materials, are common finds on central London waterfront excavations (Append. 6). However, the vast majority of this material appears to derive from breaking up vessels for reuse rather than new building or repair, thus it is not considered here (but see Chapt. 4).

8/2/3. EVIDENCE OF SHIPBOARD IN TRANSIT?

A small group of late medieval, radially cleft, oak boards from the SE Baltic region can be seen in the Polish National Maritime Museum in Gdansk. They were part of a mixed export cargo found in an excavated 14th century wreck. The minimally trimmed oak boards could have been used for shipbuilding work, or other crafts where cleft board was employed. They were all roughly 2.3-2.5 m (c.8') long 230-300mm wide and 30-40mm thick, and axe bucked from a straight grained parent oak well over 200 years old (fig.89,g).

8/3 ICONOGRAPHIC SOURCES FOR ILLUMINATING MEDIEVAL ENGLISH SHIP AND BOAT BUILDING

Although they are typically highly stylised medieval images of shipbuilding from England and the nearer parts of NW Europe are a source that can also be critically reviewed for relevant information.

8/3/1 EARLY MEDIEVAL SOURCES

The key set of images here is the late 11th century Bayeux tapestry. Descriptions of the scenes showing building of the Norman invasion fleet are numerous (eg. McGrail 1987:151., Fenwick ed. 1978:185). Most have focussed on the tools shown, narrow felling axes, 'T' axes for board smoothing, augers, and possibly other types (fig.81,a). These areas are also amenable to other lines of enquiry such as toolmark study, and ethnographic and experimental work. However, one image that has not received comment is the rather clear image of trimmed freshly made shipboards being stacked up in a tree, in the wind. This could be interpreted as a representation of an attempt to promote some degree of seasoning, prior to use (see Chapts. 7/6/5). This might help to reduce shrinkage slightly and aid in bending the boards. Other early medieval iconography tends to depict stylised views of completed vessels aiding discussions of hull form, rig and some gross structural features, but not the woodworking involved (eg. Rieck and Crumlin-Pedersen 1988:131).

8/3/2 LATER MEDIEVAL SOURCES

The survey of the source material from the whole of Europe by Unger need not be extensively summarised here (Unger 1991). However, we can say that most shipbuilding images show either a crude translation of carpentry in progress or an image of a shipwright trimming a board with an axe with a partially complete clinker built vessel in the background (fig.91,a). Experiment shows that the hewing benches shown in this image of c. 1315 are highly practical for the work of smoothing and shaping rough cleft boards. Interestingly scarfs in strakes are usually emphasised in later medieval images perhaps indicating the use of joints with slightly proud ends (Table 2). The impression given is also of the predominant use of many short boards to form the bulk of the strakes (fig.91a). It is also interesting in that it appears to show building outside and the building yard in a rural, possibly even woodland setting.

8/3/3 SIXTEENTH CENTURY IMAGES

In the 16th century we get the first really naturalistic images of boat or ship building work, in both clinker and carvel styles. Although space does not permit a full discussion of these attention must be drawn to one particularly useful example (fig.91,b). This detail from a Dutch painting of 1565 shows us several interesting features bearing on the archaeological evidence discussed in chapters 7 and 9 for clinker boatbuilding. It also contrasts with the preceding image in that the building work is going on at a shipyard site inside a building.

a/ The small double ended clinker vessel is clearly being built from particularly short, narrow cleft boards, also typical of English finds of the 16th century.

b/ A small adze is apparently being used for board trimming and scarf cutting, rather than an axe.

c/ A 'clencher and holder' appear to be working on the port side, with a shipwright on starboard, shown larger possibly to emphasise his higher status?

d/ 'Sways', small one piece wooden braces are much in evidence for boring lap fastening, and spike holes.

e/ No moulds are being used to support planking, but plenty of shores and some nailed on temporary cleats.

This picture could be taken as a graphic summary of many aspects of clinker building practice in the transitional period of the 16th century, but relecting earlier practice. Some other 16th century images also show features of interest such as the introduction of sawing as common place in carvel shipyards and the extensive nature of building scaffolds for large craft (eg. fig. 3.15 Friel 1995).

9 SOME KEY CHANGES IN BOAT AND SHIP BUILDING PRACTICE IN RELATION TO CHANGES IN THE PRACTICE OF CARPENTRY AND WOODMANSHIP C.900-1600 AD

The aim of this chapter is to draw out, interpret and summarise key information brought to light in this study, particularly that bearing on wider social, technical and environmental issues and patterns of change over our period. Brief comparisons will be made to related work carried out on 'land woodwork' to highlight what is or is not, distinctive to the nautical evidence.

9/1 BUILDING SIMPLE MEDIEVAL DUGOUT BOATS IN A BROADER CONTEXT: PEASANTS BOATS?

It is clear from archaeological finds that the most basic and numerous category of wooden boat up until the later medieval period in England was the small dugout boat. A detailed study of an example of such a craft was dealt with, including references to other vessels, in chapter. 5. It was shown that although such boats were technologically simple a detailed study can bring out evidence of importance for understanding aspects of socio-economic life, the cultural environment and woodworking practice.

Building small dugout boats was not simply a matter of scaling up procedures used when making common place 'treen' items such as feeding troughs. The toolmark evidence often suggests that a larger tool kit was used as well as a larger work force than that required for treen work. For example, it is unlikely that all but the wealthiest peasants had such specialised tools as the large broad axe used to fair the sides of the 13th century Wasdale Beck boat (Goodburn Forthcoming a). This was probably also true for some of the four classes of edge tool or range of augers used to build the 10th century Clapton boat. Ethnographic observations of dugout boatbuilding frequently indicate that one or two workers were typically part-time respected specialists in this work helped by several other less skilled men for the initial stages (eg. Reynolds 1968:117, McGrail 1978:64 etc.).

The need for a skilled senior worker

A partially specialised organisation of labour reflects the considerable investment in time, effort and material required for building even a small dugout boat. Ruining a feeding trough that had only taken perhaps a person/day to make was no great disaster, ruining a part built dugout boat that had absorbed 20 times that effort and a moderately large oak log was another matter.

Experience gained through the experimental reconstruction of seven simple, whole-log, boats (Append. 4), allows a realistic estimate to be made for the time taken to build a typical small medieval dugout vessel. For an oak vessel of c.4m length, with a beam of c 0.65m and depth of c 0.40m the overall man/days for building the hull might be in the region of 20 days, from finding the tree. Boats hewn from half logs would often have been built more quickly but would generally have had less capacity and stability. Very recently (2001), it was possible to test the suggestion about relative building time during the building of a reconstruction of a 7th century oak dugout boat Amberley 3 from Sussex using Anglo-Saxon type hand tools. The boat was of similar size to the Clapton boat with a beam of c. 0.65m a depth amid ships of c. 0.38m but was longer at c. 4.5m as opposed to 3.75m. Allowing for delays due to the museum situation of the work, the mid summer heat and inexperience of part of the workforce a ballpark figure of c. 15 man/days for 'building' or carving the boat can be suggested. If the timber for such vessels was slow grown and straight grained the work might have finished noticeably faster, but see below.

A lack of evidence for buildings small expanded dugout vessels in the SE of England

An area not explored in depth for this study was the building of small expanded dugout boats which appear to have been used by some Anglo-Saxon communities and other peoples of early medieval NW Europe (Crumlin-Pedersen 1990:105). The expansion process enabled the builders to escape the confines of the parent log and produce a more seaworthy vessel. Recent experiments based on expanded dugout boat impressions from Bornholm in Denmark have shown that what was thought by some to be impossible with oak was in fact feasible (Crumlin-Pedersen 2001). The building of expanded dugout boats such as that from Smallburgh in Suffolk or Stanley Ferry in Yorkshire, required a greater labour and skill input to hew the very refined and regular hull needed than building a simple dugout. By the beginning of our period the technique does not appear to have been very commonly used in SE England for small vessels. Perhaps these were generally small planked vessels or extended dugout boats by then, although one small boat rib timber from Thames Exchange in London may be secondary evidence of the use of an expanded and extended dugout in late 10th to 11th century London (7/3).

Dugout boatbuilders obliged to use second quality timber

As early as the tenth century there is some evidence that choice of trees was restricted for dugout boatbuilding in some areas. The c. 0.8m average diameter parent log used by the builders of the Clapton boat was relatively large but had spiral grain and some substantial knots which in practice greatly increases the work required to hew it out (figs.40,93,). Conversely a typical log used for cleft shipboard production for contemporary planked craft was larger (c. 1.0m dia.), much straighter grained, with smaller and fewer knots if any (7/6/4 above). Thus, the parent log for the Clapton boat was second quality timber in the earlier medieval nautical context. This type of distinction in the use of higher and lower quality timber has also been seen in contemporaneous shipboards and dugout boats from Hedeby (Crumlin-Pedersen 1997:183).

The secret boats of the medieval 'under class'?

The lack of historical and iconographic evidence for medieval dugout boats and their building suggests their status was common place and lowly: the craft of people for whom records were not kept since they bartered and exchanged services rather than money. Indeed, it is likely that the boats owners may have had a customary right or 'bote' entitling them to use a moderate quality log or short tree every now and then for building themselves a boat. This system of botes is known in the related fields of wood and timber use 'firebote', 'gatebote', 'housebote' and 'hedgebote' etc. (Rackham 1976:83-4). The forms of dugout boat known typically vary markedly from river system to river system in medieval England (McGrail and Switsur 1979, McGrail 1989:103), and at c3.0-6.0m long they were clearly local craft for local folk and short haul use. In the case of the distinct R. Lea finds for example, they have all been short punt-like vessels with distinctive solid hewn bulkheads. However, the use of imported pine tar in the Clapton boat (Evans 1989:96) shows that the owners tapped into the burgeoning international economy in a modest way.

In sum, we may fairly categorise most English dugout boat finds of c.900 to c.1400 AD as the boats of relatively low status, members of society who probably had a hand in their building. Except in some very remote areas, dugout boatbuilding appears to have ceased by the 15th century in England, very early by the standards of most of Europe. We might speculate that this was linked to changes in woodworking technology such as the introduction of the pit-saw, and the general increase in the wealth of the peasantry after the Black Death with its ensuing labour shortages. It is also the case that England, was in most areas, comparatively short of woodland cover compared to most other regions in Europe by the close of the medieval period.

9/2 MEDIEVAL SMALL BOATS WITH AN EVEN LOWER LABOUR INVESTMENT AND RAW MATERIAL NEED THAN SMALL DUGOUT BOATS?

As there is a continuing historic tradition of the building and use of small skin (now fabric) covered craft in western England and further west and north in Wales, Scotland and Ireland we might expect that these craft were used during our period (Hornell 1973). McGrail has reviewed the secondary evidence for the early use of skin covered boats in Britain (McGrail 1987:187). However, due to the lack of structural evidence they will not be considered here in detail apart from the following comments which are derived from experimental work and ethnographic sources (Append. 4, Hornell 1973, P. Faulkner, raw-hide coracle maker Pers Com.). The labour investment required to build the mainly woven roundwood frame of a small 1-2 man coracle, including gathering the materials, must have been c. 1.5 days. The working of the raw hide cover from one mature bovid might add another day. Thus, it would be unlikely that the making of a small skin boat of the same capacity of the smallest dugout would take more than 3 person/days. The materials and tools needed were also of a lower value- a small hachet or billhook, a knife and an awl. The rod materials, most likely coppiced c. 25 rods of between three and ten years growth were not only 'cheaper' than large oak logs but would also replace themselves in as little as 3 years. Any thwart board(s) could be reused many times, or hewn from a fairly small non oak log, as could the paddle. Again it may well have been that they were made form materials available to established tenants through the customary right or 'bote' system (Rackham 1976:83) although no references to 'coraclebote' have yet been reported.

Thus, we may suggest that in investment terms these vessels were the lowest, probably belonging to the poorest peasants. A bare minimum of about seven times the labour, and twice the elaboration in tool kit was required to build a typical small medieval dugout craft such as the Clapton boat. Of course the conditions of use would also have effected the choice of small craft type. Presumably, coracles were widely used where portage was required. There is no evidence for the medieval use of rafts in England where many of our native trees will not float or float only poorly, before thorough drying. Rafts made of other materials such as dry reeds might have been possible but we have no evidence of such craft.

9/3/2 EXTENDED DUGOUTS OF THE MEDIEVAL PERIOD: TESTAMENTS TO INCREASED WEALTH, NEEDS, AMBITION, AND ACCESS TO GREATER RESOURCES?

In our period these craft are simply too late in date to be considered as missing links in the development of wooden boats (6/2) but they are interesting for other reasons outlined below.

9/3/1 EVIDENCE FOR THE CONSUMPTION OF MUCH MORE LABOUR MATERIALS AND MORE SPECIALISED WORK

In chapter 6 the trees used by the builders of the selected example boat Kentmere 1 were reconstructed in detail (fig.58). Although the oak for the base was fairly large, its curvature was not ideal, requiring the use of a special extra stealer board on one side to obtain symmetry. This suggests some restricted access to large timber. Against this we must set the considerable additional timber resources used for the upper hull and fastenings (fig.58); the small cleft boards from a medium sized oak log, probably sawn sheer planks, from another medium sized, knotty, oak log and several short ash planks, two short wide cleft oak boards for the thwarts, selected birch and hazel logs for the framing and bilge logs, about 200 iron rove nails, and 65 blind nails. This use of much greater resources clearly demonstrates the consumption of far more surplus wealth and or labour and a higher status for the craft and its owners than those commensurate with a typical simple medieval dugout. However, it is quite possible that all the wood and timber materials used were obtained through customary rights or 'botes' (Above). Although reference to a 'boatbote' has not yet been found as far as this writer is aware, the numerous botes do include reference to 'gatebotes' and 'railbotes' (Rackham 1976:83). It is just possible that the very narrow cleft boards used in the Kentmere 1 boat might actually have been made as fence rails or gate bars by customary right rather than commercially purchased (6/9).

Although the experimental work is as yet incomplete (Append.4) a very rough estimate of the person/days involved in the building a craft like Kentmere 1 can be made. A conservative estimate might be in the region of 30 man/days for the finished hull alone. If we include the time taken for the ancillary work such as, the nail and raw iron making, the overall total man/days taken might have been in the region of an absolute minimum of c.35. Thus, this might be roughly equivalent to about twice the labour investment of a simple dugout.

Some additional tools and skills were also required above those needed for simple dugout boatbuilding. The bulk of the upper hull, required the use of cleaving skills, and probably some sawing. It is quite probable, that these materials were bought in by the woodworker in charge of building the vessel. His skills straddled both those of the rustic treen worker and those of a boatbuilder. The shape of the bow with its rocker and false stem is clearly practical as well as plank-boat-like. Grown timbers also had to be found for the one piece ribs, a crude version of the sharp floors of larger round bottomed planked vessels. Treenails and lap fastenings had to be made and then fitted so as to be strong and water tight. The fitting of the rove nails required some additional tools, a small auger or sway and clenching hammer, rove set and a dolly. On balance we may suggest that although the work of rough hewing and moving the dugout base may have been a group effort probably involving the owners and or users, the rest of the work would have been lead by a man with some specialised knowledge, and a specialised tool kit. Kentmere was only about one days walk from the estuary of the river Kent where larger professionally built clinker 'keels' and possible 'cogs' would presumably have been seen in late medieval times.

A skeumorphic form as evidence of social pretension? And extension for extended needs?

It has been shown that the flaring, angular hull form was particularly time consuming and wasteful to hew out in comparison with the common place 'U' shaped cross section of most medieval dugout vessels (6/8, above). It can be suggested that this labour was invested in an attempt to copy the form of larger flat bottomed, planked vessels (fig.66). The stem carved out of solid also suggests this (fig.57). By the 16th century hard-chined craft, built of cheap, wide, sawn planks such as the Caldecotte boat (Hutchinson 1994a:126) were clearly an increasingly practical alternative to dugout vessels. Given saw technology the single tree used for the dugout base of Kentmere 1 alone could have yielded enough sawn plank to build two vessels of such a size. This fact must have been of direct relevance as a market economy slowly came to dominate feudal exchange systems, particularly as peasants started to have more disposable income after the Black Death.

The flared and deepened hull form of our example Kentmere 1, did also have some practical advantages over a simple dugout in that the vessel could carry a far greater load. Rowing rather than paddling would also have provided greater speed and labour efficiency of propulsion. Despite the level of overall investment in time, specialised labour and materials, the craft was not embellished in anyway and was clearly primarily functional. Perhaps we might tentatively suggest that it was the lake boat of a comparatively successful local farmer-peasant?

Although large expanded, and extended dugout boats were used as trading vessels in English waters in the pre-Norman Conquest period ('proto-hulcs, 7/3/1 above) we do not yet have clear evidence that they were actually built in England. They seem to have become obsolete by later medieval times. Perhaps they were replaced by cogs and other vessels built in styles more economical of labour and materials. Sculpted sawn planking, laid edge to edge may have been substituted for the dugout lower hulls. A new find of a small cog-like vessel from the R. Wesser in NW Germany appears to confirm this suggestion and will be followed up in future work (T. Weski Pers Com. 2001). It is rather fragmentary but appears to be structurally intermediate between proto-hulcs and cogs with a vestigial dugout bottom combined with sharp ends.

9/4 SOME KEY CHANGES IN PLANKED BOAT AND SHIP BUILDING PRACTICE IN RELATION TO CHANGES, IN THE PRACTICE OF LAND STRUCTURAL WOODWORK, AND WOODMANSHIP C. 900-1600 AD

It should be clear from the coverage given to various aspects of the construction of larger vessels with planked hulls in chapter 7 that there were many changes in practice through our study period c. 900 - 1600 AD. Section 4 of this chapter sets out to summarise these changes and provide some points of comparison with changes in structural woodworking on land through the period. It also tries to people a hypothetical medieval clinker shipbuilding yard with the various key types of workers carrying out their reconstructed roles. Lastly an attempt is made to compare labour and materials investments for a modest sized medieval timber framed building of c. 14th century type and a modest sized broadly contemporary clinker keel.

9/4/1 DO CHANGES IN THE DETAILS OF SHIPBUILDING PRACTICE CORRESPOND TO CONVENTIONAL HISTORICAL PERIODIZATION?

We might reasonably expect major changes in the political and cultural history of medieval England such as the Danish or Norman Conquests to be reflected in the practice of building planked vessels. Although the archaeological material is still comparatively thin we may provisionally describe some meaningful patterns.

Suggestions of a variety of Anglo-Saxon patterns of practice prior to the 11th century

The evidence of fragmentary remains from London and the Graveney boat from a few miles east of London suggests that there are distinctive, probably regionally located Anglo-Saxon features of clinker construction. These have been described elsewhere (Goodburn 1986, 1994a). Here we can summarise as follows, vessels were clinker built, using either lap treenails and moss luting in the New Fresh Wharf-style or small rawl-plugged iron rove nails with tarred hair luting in the Graveney-style. Weather any of these differences can be ascribed to old cultural or ethnic distinctions amongst the late- Anglo-Saxon peoples of SE England remains to be seen. The framing seems to have been heavy without the extensive use of cross beams or 'bitr', and the ends of the vessels could be either convexly curving or fairly straight and raking. From the Graveney find we can also see that the framing was inserted when all the hull shell was completed, not in stages as in the 'Viking' style.

Hints of an elite Danish influence

A group of several sections of distinctive articulated clinker shipboards from a locally built vessel(s) have been found reused in early 11th century contexts on adjacent waterfront sites in London (fig.82c). London was politically part of the greater Danish kingdom at this time. The material concerned has apparently Scandinavian features, such as, edge mouldings and large rove nails without 'rawlplugs' as used in the Anglo-Saxon Graveney-style fastening system. This could be taken as tentative evidence of either; a local adoption of Danish craft practices or possibly of work done by Danish craftsmen in England, although the use of square shank rove nails as opposed to round is seen as local rather than Danish by some researchers (Goodburn 1994:103, and J. Bill Pers Com.). A few other fragments of shipboards also have hints of Scandinavian practice but the bulk of the reused material from London of the same period does not show any particular Scandinavian influences. Thus, we can tentatively acknowledge signs of a reflection of the shipbuilding practice of an elite in these fragments that probably derive from a 'Viking style' longship of some form rather than a humbler vessel or one of clearly local type.

Changes after the Norman conquest?

Conversely, so far, there is no coherent evidence of any overall change in the practice of clinker ship and boat building following the Norman Conquest except in one important respect. There is no evidence of the continuation of the Graveney-style fastenings and even treenail lap fastenings are not found often after the turn of the 11th century. But we can not say weather this was due to the influence of Danish or Norman practice. However, we must also acknowledge that the quantity of evidence is relatively slight in the 12th century and more finds are likely to qualify the current view.

When we have both an increase in archaeological evidence and for the first time detailed historic sources in the 13th century AD, we can see clear changes in practice in three respects. Firstly, it appears that boat and ship builders in England had adopted the convenient Scandinavian system of building a ship with distinct lower and upper hulls. Floor timbers or 'wrongs' were inserted when the lower hull shell had been planked up. This can be seen in the hulls of the Magor Pill boat and Blackfriars No3 vessel for example (fig.96, Nayling et al 1998, and Marsden 1996) and is strongly suggested by the phasing of work in several of the 1294-5 galley building accounts (eg. Friel 86:42 re the Lyme Galley). Secondly, it is clear both from archaeological finds such as the Blackfriars 3 vessel and Poole foundry reused timbers (Watkins 1994), and the galley building accounts that the 'Viking' system of using an intermediate timber ('lot') between stems and keel was adopted for some vessels at least. The middle English term for this timber seems to have been 'under lout' or 'underloute' (Whitwell and Johnson 1926:180). In recent vernacular boatbuilding in England this feature is rare which may indicate that it was an arrangement not adopted by all boat and ship builders in England. Thirdly, it would appear that the use of multiple cross beams or 'bitr' was also at least partially adopted for larger craft, as in the galley building accounts cross beams are very numerous items. Archaeologically we have only two examples from England. The earliest is a very fragmentary broken oak bitr from a c. early 11th century building floor at the London UPT90 site. A later, better preserved example was found reused at the Kingston upon Thames HOR86 site. It was a boxed-halved oak beam with fastenings for a pair of treenailed and spiked on knees, and joggles for fitting clinker planking (fig.96a). The reuse of the timber dated to c. 1300 AD. The knotty, slightly bent parent oak log for this beam could not have been made by cleaving and hewing. It is far more likely that it was hewn square then sawn in half lengthways as was often the practice in building carpentry at this time. So many logs would have made a pair of beams.

The great shift at the close of the medieval period

It is well known that great changes in English shipbuilding practice did clearly take place during the late 15th and early 16th centuries usually taken as the end of the medieval epoch. These included the adoption of carvel building techniques for large vessels from further south in Europe (see Hutchinson 1994a:44 for a wide ranging review of this question.). Relevant to a detailed study such as this, there was also a vast increase in the use of sawn plank materials for all craft (witness the hull of the Mary Rose of 1509-11 Append 6. and fig. 86b,c). However, many boat builders continued with the modified versions of the ancient clinker system up to recent times in many areas of England.

Some very new evidence of tools transfer from south to north

It is likely that it was at this time in the early 16th century that various forms of adze became far more common as both a shipwrights and boat builders tool in England. Adzes are clearly essential for assembling a carvel built hull. New work on tool finds from the Mary Rose excavation have just thrown up a key piece of evidence here as Mediterranean or probably specifically 'Italian' style adze helves have just been recognised (C. Mckewan Pers Com. 2002). The adzes where designed to be fitted with an iron stirrup that secured the flat adze blade, such an adze blade has also just been found in 16th century waterfront land-fill deposits in London (at site ABO92). These finds hint at the transfer of tools from the Mediterranean to English ship builders and will be explored further in future work. The marks of either comparatively small bladed axes or possibly small adzes of this new type are noted in sections of chapter 7 dealing with early post-medieval keels and carvel and clinker planking.

In sum, we must accept that there was some synchronisation of changes in planked boat and ship building practice with conventional historic changes such as the Danish invasion, or the opening up of England to Italian influences in the late 15th and 16th centuries. These changes were expressed at the level of the form and structural layout of vessels or more subtly in details such as changes in types of fastenings and toolkits used.

9/4/2 TREEWRIGHTRY AS OPPOSED TO CARPENTRY AND THE DISTINCT SEPARATION OF NAUTICAL AS OPPOSED TO LAND BASED WOODWORK c.1200 AD

It has been useful to employ a modernised version of the Old English term 'Treowwyrtha' (Bosworth and Northcote-Toller 1898:1013) to describe the distinct practices of structural woodwork on land in the Saxo-Norman period (c.900- c.1170-80AD). The Middle English term 'carpenter', derived from the French, is apparently known from around 1220 AD in SE England if not earlier (Dyer 1986:37). The key features of carpentry as opposed to treewrightry have been defined in detail elsewhere (Goodburn 1992a,1995,1997 etc), and it has been noted that a great many shared features occur in both land and nautical woodwork before 1200. Fenwick also noted in 1978 that 'treewrights' seem to have been able to build boats as well as houses according to Aelfrics colloquy (Fenwick ed. 1978:188). Some of the features of treewrighting 'on land' which are sometimes thought exclusive to woodwork in the nautical sphere are listed below;

a) The widespread use of cleft boards, often overlapped.

b) The use of naturally grown, curved timbers.

c) The use of headed willow treenails, and occasionally Graveney style rove nails.

d) The use of simple axe cut joints such as through- splayed-scarfs, fastened by treenails.

e) The lack of prefabricated framing.

Though there were many similarities, in practice it seems likely that there was some degree of specialisation when it came to building large craft. This is suggested for Norse influenced areas by the use of the term 'stafnasmidir' (stem smith) in the Saga account of the building of a large longship at Trondheim in 998-999 (Christensen 1982:329). Unfortunately we have no equivalent textual distinctions in Old English sources.

The use of materials diverges; perhaps reflecting the emergence of guilds?

By the time the new carpentry was thoroughly adopted in England by c. 1225 AD the woodworking techniques and many of the raw materials used by people who built planked vessels and those who built buildings were quite distinct. By the end of the 13th century, if not earlier in England, 'shipwrights' were clearly distinguished from 'carpenters' in documents (8/1/1). However, carpenters were involved in hewing timber for shipbuilding work and working on building-like structures such as for'ad or after castles. Conversely on land shipwrights only appear to have been hired to fasten expensive doors with rove nails (Goodburn 1991:105) but little else.

The guilds

Distinct craft guilds existed in London for many woodworking trades but surprisingly the shipwrights guild was a relative latecomer in 1360 (Friel 1995:39). Whilst shipwrights working in the common keel tradition still relied heavily on using radially cleft boards, carpenters only seemed to use them for very specialised purposes. Mortise and tenon joints, fundamental to English medieval carpentry, were not used in basic hull construction. Another fundamentally distinct feature is that there is no evidence of the adoption of the carpenters practice of using fully prefabricated frames in English nautical archaeological evidence until the 16th century (see below).

As yet there is no clear evidence of changes in woodworking practices by English shipwrights working in the keel tradition around 1200 AD as has been found for S. Scandinavia by Bill (Bill 1995:200). However, the quantity of archaeological evidence available in England is rather limited. The exceptions may have been an apparently small number of builders working in the new cog tradition who may have been of Low Countries origin in any case (see below).

9/4/3 ASPECTS OF CONSERVATISM AND INNOVATION IN ENGLISH MEDIEVAL SHIPBUILDING PRACTICE IN THE 13TH CENTURY

Go-ahead cog builders

Clearly those apparently few shipwrights working in the cog tradition in England from the early 13th century did use some of the new techniques of the carpenters since sawn planks appear to have been a major raw material (Goodburn 1997a). Indeed, it can be seen in the Bremen cog of 1380 that some frame elements were converted in the same way as the curved braces and crucks of contemporaneous English carpentry. The massive standing knees, bracing the deck to the sides of the hull, were clearly sawn out from a hewn crook as matched pairs in the same way as most curved carpenters timbers in 14th century England (fig.97). The use of sawn hull planking allowed for economy in timber and other materials (7/6/6). Perhaps we see the pressure of 'market forces' at work here in the details of the woodworking as well as the capacious hull form of cogs. This focus on economy could be seen as prefiguring some features of carvel ship building, such as the use of fairly long wide sawn planks cut from logs coming from trees of only moderate quality and size.

Conservative 'keel' builders clinging to the use of radially cleft shipboards

Builders working in the more common, ancient, keel tradition in England were particularly conservative in their use of materials. Indeed, in one particular respect we may describe their use of some materials as absurd from a modern rationalist perspective. By the 14th century it is clear that cleft shipboard was generally only available, in England in relatively short lengths, often less than 3.5m or 12'(figs. 83,84, Table 1, and 7/6/4 above). By the 15th and 16th centuries the length of boards was often less than 2m. This meant that even small vessels required many scarfs in each strake and the extra fastenings to hold all together. This has clear extra cost implications also considered in the investigation of the early 16th century Stockholm find the Riddarholm ship (Lindberg 1985: end note un paginated). These small boards were even used in some very large vessels such as the Grace a Dieu (Burseldon ship) of 1416 in a curious system of three laminations (fig.94a, Hutchinson 1994a:30). In shell-first clinker construction without moulds it is, in practice, very difficult to pre-bend short radial boards over about 50mm thick. This meant that the necessary hull thickness for large ships, particularly those meant to resist the impact of cannon shot, was very difficult to achieve. This must have been a key factor in the adoption of sawn planking and possibly carvel building methods where the longer, wider and thicker tangentially faced planks were actually proportionally easier to bend than the short thick cleft boards.

Some subtle economies with the adoption of sawn planking

Although tangentially faced sawn planks are not as strong and stable as cleft board they have a number of advantages for economy minded hull construction (see 7/6/6) and below;

a) They can be produced from trees of varied quality, and modest girth compared to those needed for cleft ship boards (fig.86,b)

b) They can be bent more easily, and produced and worked in thick standardised sections.

c) They would often require less trimming for use in large hulls.

d) They can easily be made longer and wider than radially cleft board.

A counter factor

However, early in the medieval adoption of sawing technology sawn plank must have been expensive to produce in labour terms. Experimental work and living testimony of sawing in the 1940's suggests that about 12 square feet of cutting was an average hourly rate of work in pit-sawing (Harris ed.1997:53, Append.). This might be about 100 square feet a day in good conditions and a strong healthy pair of sawyers. Experience with sawing on one or two trestles is beginning to suggest that the rate of production would have been a little lower than that using the older method. As a very rough average rate of production this compares with the documented clovyers rate of around 120 square feet (8/1/1 above) for roughly finished shipboard per day with suitable timber. Two or more people were required for the sawing only apparently one(?) with simpler cheaper tools for the cleaving most of the time. However, a rough cleft board required much more trimming before use than a sawn equivalent.

Given that cleft shipboard was also, stronger, more stable in use and the material used for 30-40 generations of clinker boatbuilders in England up to c. 1200AD the continuing use of the material becomes more comprehensible.

However, by the 16th century it is clear that the overall economic advantages of using the sawn planks for much of the hull were finally accepted by boatbuilders working in the keel tradition in SE England and elsewhere (Bill 1997). Interestingly in England sawn and cleft material were actually used together in the 16th and early 17th centuries. By this time the extreme shortness of the cleft boards and their narrowness, 1.8m by 15cm wide in the case of JAC 96 examples (fig.84,d), could indicate that they were made by using a different technique to the earlier wider boards. This might have been the highly controlled method of 'froe and brake' cleaving (fig.94,b) used into the 20th century for cleft oak fence pales, cask staves, and gate bars only a little smaller than the late 16th century ship board. This has been tested experimentally and works well for the last subdivision of 1/16th 'clefts' into 1/32nds, for radial oak boards of 2.2m length and up to 170mm width (Append.4). However, it could not be used for much larger boards due to the weight and width of the timber.

9/4/4 A LINK WITH RECENT TRADITIONAL ENGLISH CLINKER BOAT BUILDING PRACTICE?

The adoption of wide pit-sawn planks as a raw material for hull boards appears to be linked to subtle changes in the practice of building clinker hulls. In recent English traditional practice it is often the case that one board might be cut from one side of a sawn slab, avoiding the weak pith, and another from the other half (fig.95a). Many of the finished boards then resemble the narrow cleft boards of the 16th century, but are longer. In many cases another practice follows in which a finished board is used as a pattern for marking out a matching board on the opposing side. This helps maintain symmetry, and can result in the heart face orientation varying around the hull. Interestingly this practice has also been recorded for the Bredfjed boat of c. 1600 AD from Denmark, where it is termed 'mirror planking' (Bill 1997:22). A 17th century clinker hull fragment from BEY95 may be tentative evidence of the practice of using half a sawn slab for a finished board (fig.84c) but too little remains to discover whether the method described above was used.

9/4/5 BORROWING FROM ESTABLISHED CARPENTERS PRACTICE IN CARVEL BUILDING BY THE LATE 16TH CENTURY?

It is now well known that forms of carvel construction known from just across the North Sea did not always require the pre-fabrication of full frame units as in recent English practice (Maarleveld 1994). However, it has been suggested that the practice of erecting a fully prefabricated skeleton of backbone and accurately made frames was adopted in England in the late 15th to 16th centuries for large vessels (Hutchinson 1994:44). Whether this was so or not it is clear this was a particularly important development. We might tentatively suggest that this practice was easy to assimilate for some shipwrights who were familiar with the long established carpentry practice of prefabricating accurate truss frames, which in the 15th centuries often had many curved elements.

The elaborate deck framing found in large 16th century carvel built ships such as the Mary Rose parallels the compartmentalised floor framing in contemporary large buildings. The ship deck beams may equate with bridging beams, the 'carlins' (secondary fore and aft beams) with secondary main joists and the ledges' (light deckbeams) with common joists. Indeed, the adoption of the true watertight deck was a crucial development which is not currently understood or closely dated. This is another question to be addressed in future work.

It is not clear whether vessels such as the Mary Rose of c.1509-11, had entirely fully prefabricated frames as this is still undergoing investigation (Dobbs Pers Com). However, it is quite clear that carvel built vessels with dovetail keys between the floors and futtocks, such as the Cattewater wreck of c.1500 (Redknap 1984:99) must have been built around a prefabricated skeleton which does clearly seem to be an Iberian technique. The frames could not have been assembled end on in phases during or after the hull was planked up.

Clearly another borrowing or parallel practice was that of using many pit-sawn elements in ships like the Mary Rose. In that ship observation shows that the largest elements such as deck beams were hewn boxed-heart, whilst secondary deck beams and knees were often hewn then sawn in half box-halved style, and finally the minor beams and stanchions were normally sawn out of thick sawn slabs. This mirrors the patterns of conversion seen in the floor frames of large buildings of the late 15th to 16th centuries. So the parallels are not just of form but also in details such as the working of the timbers.

9/4/6 TOOL KITS AND TOOL USERS; AN ATTEMPT TO RECONSTRUCT WHAT NAMED CATEGORIES OF HIGH MEDIEVAL SHIPYARD WORKERS ACTUALLY DID

A synthesis of the archaeological evidence (Chapt.7); the historical and iconographic sources (Chapt.8), tempered by experience gained through experimentation and access to relevant ethnographic sources (Append. 4, and Crumlin-Pedersen 1986b, Andersen et al 1997) allows us to attempt an outline, reconstruction of what the various categories of shipyard workers actually did in building a large clinker, keel-type vessel in later medieval England (13th to earlier 15th centuries). The roles of some ancillary workers based at the shipyard are fairly explicit eg. 'man making treenails', or 'carpenters making store sheds' (Friel 1986), but the precise roles of the different named categories of craftsmen who actually put a hull together have not been clearly defined. It has also been shown by Friel that many projects did not apparently have a single master shipwright in charge, and even where they did his supervision appears to have been intermittent (Friel 1995:51). Thus, we have to see the control of many projects being in the hands of a group of senior men rather than one individual.

A step by step, hypothetical, reconstruction of the stages in building a large medieval clinker hull are annotated below (also see fig.2, table 5, and 8/1/1 above).

1) On the agreement of a contract, between the owner or his/her agents and a group of senior master shipwrights, they would rapidly set about planning the work, finding and setting the specifications of suitable timber, boards, lap fastenings, lap and scarf proofing materials and establishing a building site. Much of this work, such as timber conversion was carried out by others, carpenters, clovyers, labourers, merchants, and increasingly at the end of the period sawyers.

2) The delivered. roughed-out centre line members ('great timbers') would then be trimmed to shape by shipwrights, fitted, and shored in position, according to

traditional rules of proportion, or occasionally to the proportions of foreign craft (Johnson 1927).

3) Along side the above, the boarders ('berders') would presumably have been hewing the rough cleft boards reasonably smooth and to the cross section required by the master shipwrights (figs.80c.and 91a).

4) Next the garboard hood ends aft would be cut out and preformed by hewing and or bending sometimes with the aid of fire (fig.87), these would be 'offered up', remarked, trimmed and then clamped and shored into position. Often board fitting would have principally involved the trimming of the edges, ends and the laps, following the work of the boarders. This fine trimming appears to have been accomplished with considerable skill, principally with axes; very wide 'T' axes in the pre-Conquest to 13th century period (fig.82a), by the 14th century narrower bladed broad axes (fig.83,a,b). By the 16th century even narrower bladed hachets or possibly small adzes were used (fig.84a,b), perhaps adopted from carvel ship work? It is likely the most skilled master shipwrights did this work perhaps assisted by less senior journeyman shipwrights ('berders'). The planking-up would then proceed working for'ad from the stern post (after stem) and then starting again aft, strake by strake to around the turn of the bilge.

The position of the top inside edge of each clamped board and its angle of fit would presumably be checked by the master shipwrights eye and with simple stick measurement from a centre line and a boatlevel of some type (Christensen 1972:242, Andersen 1997:29-33, Vadstrup 1997:102). Once all was correct, the lap and scarf fastening pilot holes would then be bored finally fixing the position of the hull boards.

5) Following behind the shipwrights, the clenchers and holders presumably carried out the next stage of work. The boards would be removed and the laps and scarfs luted in the local style (Append.11), with the fibrous material set in a mastic of wood tar or resin. Sometimes this luting may have been prepared by wives of the builders (Walton 1988:85). The boards would then be carefully repositioned and clamped. The lap fastenings, generally iron nails, would then be

driven by one of the pair (the holder?) whilst the other supported the boards with a dolly inboard. A dolly would then be placed against the nail head and the prepunctured rove driven on tight. Lap treenails would be split and a wedge driven inboard to achieve a locking effect. The clencher of iron rove nails would then hammer the nail tip for'ad or aft against the rove to lock it and proceed to clench it, by blows from a sharp chisel peine hammer (or cold chisel? figs.82c, Append.9). Usually the hammers chisel end would cut off the nail tip, but occasionally this was left behind in hurried work (fig.84c). It required some skill to achieve a neat strong clench without bruising the board adjacent to the rove.

It is quite possible that there was a dance-like rhythm to the work; effectively a slow procession around medium sized vessels of the clenching and boarding teams whilst in larger craft the groups presumably worked for'ad then passed by each other and started again aft on the next strake, all this against a rhythmic ringing of the clenching and hewing. In practice clenching produces a double rhythm of a main metallic blow followed rapidly by a quieter tap as the dolly bounces slightly on the nail head.

6) The shipwrights would then hang another board, broad axe and sometimes shave trimming the upper laps and edges of the boards already clenched for a good fit. If marked asymmetry developed small adjustments could be made to the width or angle of board fastening and or shores to compensate.

7) Once the planking had proceeded up to about the level of the turn of the bilge it is likely that all the floor timbers were trimmed, marked and fitted, as the access was easy at this point. This work was presumably carried out by the boarders and shipwrights assisted by the less senior craftsmen. Sometimes the fitting of the treenails securing the floors was delegated to others (Friel 1986:43), who bored for them with long spoon augers from the inside so as to keep them alined in the floor timbers. This lead to some treenail heads awkwardly touching lap edges on occasion, most strakes were treenailed to each frame but not the keel. The heavy, awkward keelson ('mastspore', Johnson 1927:432) was probably fitted over the floors at this point in large craft, followed by low cross beams ('Schebemes', fig.96,a.).

8) It is likely that some surface treatment of the hull timbers took place at this point to control seasoning.

9) Any long sawn and hewn timbers for the upper works of a hull would be roughed out by sawyers at about this point and more framing timbers ('foteken') and boards would usually be bought.

10) The cycle of board 'hanging' and clenching would then continue up to sheer level with the aid of staging, and the futtocks, and any further beams fitted.

11) Extra bracing in the form of knees and stringers would now be fitted.

12) Any sealing or deck structures would then have been built sometimes involving carpenters.

13) Finally, the hull would be given a durable surface finish with some rot preventing treatment by other workers. In some particularly high status vessels decorations were applied by painters and carvers (Append.12) and might even include such refinements as tinning iron nail heads (I. Panter Pers Com. re the Kingston Horsefair boats).

14) The vessel would then be launched often involving the services of many labourers, followed shortly afterwards by substantial repairs and rebuildings in some cases (Johnson 1927). This may have involved the patching of splits caused by seasoning (particularly in sawn planks), tightening and adding to fastenings and possibly adding additional framing, and deck structures? Perhaps the vessels were built at the limits of the knowledge and skills of the builders? The concept may have been alright in theory but as with some military technology today, the practice proved more problematic.

As set out in the first chapter this study does not set out to examine the important areas such as the masting and rigging of craft, the next stages of work, which may often have taken place afloat.

A simplified work force structure for building medium sized and small craft

The accounts dealing with building smaller craft, such as the Bridge House accounts (Spencer 1996, and 8/1) clearly indicate a less stratified division of the work force. In practice some of the work differentiated above must have been shared, between senior and less experienced shipwrights in building many medium sized and small clinker vessels.

9/4/7 THE CONSUMPTION OF MATERIALS, AND MANPOWER AS MARKS OF STATUS AND COMPARISONS WITH LEVELS OF LABOUR AND MATERIALS INPUT IN CARPENTRY

The volume of timber used for constructing large planked vessels was unsurprisingly large for example 12,400 ft of boards are listed as having been used in the of the Southampton Galley of 1294-5 (Friel 1986:42). The vessel may have been double skinned? Even the smaller Lyme galley hull required the use of 741 boards amounting to 7,370 ft (Friel 1986:43) and average length of board of just under 10'. These boards might have come from c. 25 large parent logs if mainly radially cleft perhaps with some of the longer planks sawn. If the timbers for the centre line, framing, cross beams and deck structure are added the volume must have been enough to build the frames of several timber framed houses with lath and daub infill. The other materials used also had to be employed in huge quantities such as over five tons of iron nails for the Newcastle galley of 1294-5 (Hutchinson 1994a:23). An amount equal to that needed for a great many substantial houses, for fastening tile battens, hinges etc.

Labour investment as a mark of the status of a vessel and its owners

We can also see that the overall use of manpower in the building of large high medieval clinker ships was phenomenal (8/1/5). For example it took at least

3,000 overall man/days to build the basic hull of the comparatively small Lyme Galley with a probable keel length of c. 55' and 54 oars in 1294-5 (Friel 1986). For a modest sized clinker river keel the building of the basic hull would have taken at least 200 overall man/days, probably more. Thus, a large clinker ship would have required very approximately 150 times the labour input of building a simple small dugout or about 15 times that required to build a clinker river keel. A graphic reflection of concentrated power and wealth applied to the maritime sphere in high medieval England.

How did this compare with the labour investment required for carpentry projects on land?

No large timber framed buildings have been built using medieval technology in recent times so accurate comparative data is not available. Nor have medieval building accounts undergone critical reassessment based on detailed archaeological recording. However, the recent renaissance in building green oak framed buildings in England to traditional forms is starting to provide some comparative data, although most of the work is carried out using power tools and other modern labour saving devices.

An exception, in which this author had some involvement can be outlined below. It took very roughly 320 man/days to make and erect the basic frame work of a two bay (24'x 15'-7.30 x 5.55m), framed cruck building with a half loft. This structure is very similar to a rather solidly built c.14th century English cottage of west Midlands type (fig.97). Here the figure presented includes estimates for the medieval style replacement of a few tasks that were carried out using modern power tools such as the felling of the oak and a few sweet chestnut trees used. About 80% of the timber was converted by hand using tools and methods of the 14th century, a combination of hewing with narrow then broad axes followed in many cases by sawing using the see-saw method (Append.4). Additionally only about 1/3rd of the work force had much experience of that type of work, and the days worked were not as long as was likely in medieval times. If an allowance is included for these factors but an addition made for the roof covering, foundations and infill of the frame a very rough estimate of the time such a building would have taken to build in the 14th century is c.300-350 person/days. This overall labour estimate is perhaps a roughly equivalent to or a little more than that for the building of a clinker river keel or 'shoute' (see above) including its rigging sail and equipment such as a rudder, sweeps, bailers etc. A factor to consider here would be that whilst the boat might have a usable life of perhaps up to 50 years, though c. 20 is more likely, the building could last several hundred years with basic maintenance.

The quality of the timber used for the shipboards and the volume of iron for the rove nails would have made the boat very much more expensive in materials. The issue of the comparative quality of materials used with in early medieval shipbuilding and in comparison with woodwork on land has very rarely been considered. An exception being the work of Crumlin-Pedersen in his analysis of the early medieval nautical finds from Hedeby (1997:93,182). He suggests the exceptional 10m long radially cleft boards used in parts of the large Hedeby I long ship of c. 985 AD indicate very high, possibly royal status. Buildings in contemporary Hedeby did not apparently use timber of quite such size and quality. The long shipboards are the largest known of their kind in medieval N Europe. One might also suggest that the boards were probably labouriously hewn down from 1/16th cleft sections rather than thinner, shorter 1/32nd sections, so both the materials and labour investment can be seen as exceptional.

A regional peculiarity against the trend of decreasing size in the use of radially cleft oak shipboard in later medieval times seems to apply in the SE Baltic region due to the late survival of large areas of lowland wildwood in the hinterland. It is clear that very large, flawless shipboard was still used in some vessels built there as late as the 15th century if not later. For example, some 15th century radially cleft oak shipboards on display in the Polish National Maritime Museum in Gdansk, were flawless and up to 8.3m long and 0.32m wide, clearly cleft from selected, slow grown wildwood oaks. Typical English produced late medieval cleft boards were very much shorter rarely, if ever, over 3.5m long (Table 1.) by this period.

9/5 IS THE RECENTLY ESTABLISHED RECEIVED VIEW OF THE NATURE OF WOODMANSHIP IN MEDIEVAL ENGLAND ALTERED BY A DETAILED CONSIDERATION OF THE NAUTICAL MATERIAL?

The received view of the general and locally specific nature of later medieval English woodland and woodmanship has been developed through the pioneering work of Rackham since 1972 (Rackham 1972,1976,1980, 1986a, 1986b). He used direct observations of timbers in standing medieval buildings, existing ancient woodland, iconography, and documentary and cartographeric sources for his reconstructions of woodland and woodmanship. He was not able to examine contemporary remains from excavations of medieval structural woodwork of all kinds available, particularly in London periodically from 1972 (eg. Tatton-Brown 1975, Milne and Milne 1982, Milne et al 1992). Nor were ship wreck finds or the results of tree-ring analysis of early timbers generally drawn upon.

His general view for the high medieval period could be summarised for our purposes as; woods were managed primarily for producing fuel wood, and small roundwood for fencing by coppicing, with relatively small timber trees (< 0.5m diameter, 'standards') growing amongst the more valuable and regularly cut underwood. Some larger timber trees appear to have been allowed to grow in hedgerows, and open wood pasture, together with pollards managed mainly for fuel-wood production. The last areas of high dense wildwood in England with very, large, tall oaks appears to have been converted into managed woodland by about 1250 AD eg. the Forest of Dean.

During the 16th century timber used by carpenters was often derived from larger girth trees principally of hedgerow or park origin, sawn into sections. Far more elm was used from then on. Importantly he sees shipbuilding as a generally minor force in the shaping of post-medieval English woodscapes contrary to popular assumption (Rackham 1986b:91), however, he has not examined the nautical archaeological evidence in detail as he has selected standing building evidence.

Updating and refining some of Rackhams generalisations on the nature of medieval treeland in SE England from the late 1980's

Some revision of aspects of this received view have been required through systematic analysis of carpentry from the London waterfront excavations, for example we can see that the boles of medieval pollards were also valuable in some cases for timber ie. short, wide, sawn plank (Goodburn 1994b:659). For the earlier medieval period, described as part of the 'Dark Ages of Woodland..' by Rackham (Rackham 1976:49) due to apparent lack of documentary evidence, much information has been derived from excavated woodwork (Goodburn 1992a, 1994b, 1997b, 1998, and Append.2). Key here has been the widespread evidence for the reestablishment of wildwood type conditions in substantial areas of SE England in the Anglo-Saxon period. This work provides a backdrop for the following comments.

9/5/1 WHAT SPECIFICALLY CAN NAUTICAL WOODWORK TELL US ABOUT HISTORIC WOODMANSHIP AND DOES IT CORRELATE WITH THE PICTURE DERIVED FROM THE STUDY OF LAND-BASED STRUCTURAL WOODWORK?

Chapters 5, 6, and 7 have attempted to describe in detail the character and range of timber used in the building of examples of simple medieval dugouts, more complex extended dugouts and plank built craft. The 'parent trees' for a representative range of elements have been graphically reconstructed (figs.40,58,70b,74b, and 81b,).

The Saxo-Norman overview

For the Saxo-Norman period we may suggest that the current evidence indicates that new high quality boards made from large 'board trees' were used for demonstrably expensive high status structures weather on land or water (fig.93 Goodburn 1992a). A particularly solid, expensively built, wharf could be built from huge, high quality wildwood board trees even as late as the 1180's or from small roundwood and reused timber at the other extreme. In boatbuilding it is clear that some dugout builders had to make do with timber including undesirable features such as spiral grain and large knots, whilst builders of most planked vessels had the pick of larger straighter board trees (fig.93). In sum, medium sized and large vessels built with clinker hulls did require many large, slow grown board trees for the planking (Tyers 1994a). The framing timbers were generally modest sized , often crooked logs coming from smaller crooked oaks and the tops of some wildwood trees. However, there is not yet clear evidence for treewrights building clinker craft having had a predominant choice of materials. This is in clear contrast with the picture from Hiberno-Norse Dublin (Wallace 1982, McGrail 1993) where almost all the houses excavated were built of cheap roundwood and hardly any new oak timber, whilst the fragmentary ship remains showed large board-quality oaks were normally used to build them. At present we might chose to read the Dublin evidence as suggesting that there were many restrictions on the use of high quality large timber for the vast majority of buildings but something, or rather someone(?) else made that valuable material freely available for clinker ship and boat building. It may be that we are seeing evidence of the broad control of an elite here. As clinker building appears to have been an introduced Scandinavian craft technology the elite concerned may well have been of Scandinavian (Norwegian) origin, at least initially.

The high medieval overview

By around 1300 if not earlier it is clear that cleft shipboard was being produced from faster growing, and sometimes less straight grained trees. Such that where a 10th century shipboard might have been taken from a 2-300 year old tree the

14th century equivalent would have been cleft from a log from a tree of little more than half that age (Table 1). However, the boards were often a similar width to those of the earlier period, indicating that the girth of the parent trees was similar and must have been around 1m diameter at chest height . The implication is that the parent oaks grew either, as particularly large, straight, woodland standards (fig.98c) or, in small groves of large timber trees (fig.98b), a possibility Rackham has hinted at (1976:83). This may suggest that Rackhams 'oversized' trees were rather more common than allowed for in the received view.

It is clear that only the bottom, least knotty, 2-5m of the parent trees was used for board making (fig.98b.), except perhaps for a few really exceptional trees, that could produce more than one board log or were unusually tall to the first main branches. This would have left the second and possible third logs for hewing and or sawing into planks or beams. These may have been used for local carpentry use. A very similar tripartite sub division of large timber oaks is still practised in the Troncais region of France today (fig.99a), but in England it is very rare for more than two logs to be cut from one timber oak. Interestingly, Rackham has examined a 14th century timber building where large numbers of butt logs seem to have been 'missing' (Rackham 1986a:43). It is very tempting to suggest that they may have been used for making shipboard, particularly as the building lies close to the Thames estuary near Southend. The galley building accounts of 1294-5 and some archaeological shipboard finds in England show that some shipboard was also imported, from the SE Baltic region (8/1/4, fig.98a, Tyers 1996a). This was clearly board made from remaining sections of lowland wildwood in the hinterland of that region.

Shipboard is also documented as being exported from Ireland in the later medieval period (Hutchinson 1994:150). Very recently such slow grown, Irish wildwood boards have actually been found in part of a late 13th century galley found reused in London (Append.6 TYT98 entry, Tyers 1999,). This material was found too late for full coverage in this study although it has been briefly cited in several places above where relevant but it will be covered more fully in future work (eg. Goodburn Forthcoming d and elsewhere). Here we can just note that the large vessel was probably built in Ireland including at least one reused

Irish board, later she was massively rebuilt in England, or possibly SE Wales, where a beech orloke plank was fitted. Beech is not native to Ireland. Also some apparently local fast grown oak boards and eventually at least one sawn oak orloke plank were also fitted as repairs.

Some of the heavy upper branches of these large board trees and shorter more spreading forms would probably have provided curved elements for framing, and knees. However, woodland standard oaks typically do not produce many large branches suitable for large vessel framing, and more open grown oaks must have been sought (figs.98d,e)

Evidence of overlapping demand for certain types of timber between carpenters and shipwrights.

The hypothetical parent trees used for keel timbers both in the pre and post-Norman Conquest period have the long straight and lean characteristics that also appear to have been sought for large building roof timbers such as collar purlins or principal rafters. If the rare example from Kingston (fig.96a.) can be taken as representative it would appear that large boat and ship cross beams, of c. 1300 at least, were very similar to contemporaneous building posts and beams. In this case a fairly small, knotty oak log was hewn square and apparently halved by sawing, producing two matching beams. It may well have been a 'top log' from a modest parent tree. The similarities of this class of nautical timbers to those in carpentry work would have made it easy for carpenters to rough them out to the specifications of master shipwrights as is documented in the 1294-5 galley building accounts.

Changes in the 16th century

With the dramatic increase in shipbuilding and typical ship sizes in the 16th century, the impact on some local treeland resources must have been considerable, if periodic. The scantlings of vessel elements also increased greatly. Few 16th century large vessel timbers have been studied from this point of view, but some reused early to mid 17th century examples have been examined in detail (Saxby and Goodburn 1998, Goodburn 1999b). In general, the work indicates the types of treeland resources used were very similar to those used for contemporaneous carpentry. Typically large structural members were pit-sawn sections of fairly large (0.50-0.90m diameter, fig.100) fast grown oaks, of open land, hedgerow or parkland form. However, some smaller framing elements, and lighter timbers were probably of woodland origin, and were hewn from smaller logs. Clinker planking was also pit-sawn from medium sized, fairly fast grown oaks with some knots (figs.86d, 95d). These features would be typical of a smallish coppice-with-standards timber oak today.

The use of a new species group

Importantly a new native species group, the elms, were extensively used from the about the mid 15th century in London waterfront carpentry (Goodburn 1992a:108). The boat builders timber stock pile of 15th century date found in Poole Hampshire, also included some elm. However, we do not have evidence from the London yet for the use of elm timber in boat or ship building until a little later in the 16th century. It appears that the less durable elm was used, mainly but not exclusively, for longitudinal elements such as keels (fig.73) and lower permanently wet hull planking. Some elm was also used in later work in the Mary Rose such as in the planking of the lowest or 'orlop' deck. Although elms did grow in woods they were, until very recently, the classic hedgerow timber trees of SE England. They were common along the shores of the later Medieval Thames in its middle and lower reaches and have even been found as waterlogged stumps in situ on London waterfront excavations eg. at Hays Wharf Southwark (Spencer 1996:209). Now they can still be found in hedgerows on the flood plains of the Thames and Medway although most are badly effected by the current wave of Dutch elm disease. A key feature of the elm family is that it will usually grow fast and comparatively straight even in rather open conditions where oaks tend to branch out lower down. This feature can now only be seen in

SE England in trees of the Brighton area E Sussex, today, where the dutch elm disease has been kept at bay.

The last traces of clovyers work

In some clinker built boats and the upper works of some carvel ships such as the Mary Rose, cleft oak shipboard was still used but in increasingly smaller sizes (fig.84d.). We must ask why were these boards made so impracticality short, often as little as about 1.85m (6') long. A possible answer may be that they could only be cleft from the short, straight, large diameter butt logs of selected parkland (woodpasture) oaks. Today suitable parent oaks of this form can be seen in some parkland settings (fig.99b). The butt logs may effectively have been kept free of side branches to a height of around 2.2m by the intensive browsing of large deer, cattle and horses. The increasing use of cross-cut saws would have allowed low felling and thus the usable cleaving log would have been about 1.9m in length. The upper stems and heaviest branches were presumably used for saw logs or large beams, and compass timber respectively. The terms 'bottemholt' and 'bottine holt' which may apply to cleft board, in at least two 14th century documents, is suggestive in this context (Salzman 1952:247). Suitable large straight oaks of this hypothetical form can be seen in some areas of parkland in southern England today, where there is a form of wood pasture in operation. The best place to see this is in the un-coniferised areas of the New Forest and rather more so the Forest of Dean.

Some imported softwood timber was clearly starting to be used in the early 16th century, mainly for spars, but occasionally for structural elements. A softwood (pine?) deck beam is claimed for the Mary Rose for example (C. Dobbs Pers Com.). Imported softwood and oak have also been found in waterfront carpentry of the period in London (Goodburn and Minkin 1997 Un Pub.).

9/5/2 THE PRODUCTION OF IRON FOR VESSEL FASTENINGS AND FITTINGS AND THE TREELAND AND LABOUR RESOURCES USED

Specialists working in the field of archaeo-metallurgy have been interested in issues of fuel supply, principally charcoal for iron smelting and smithing processes, for some time (eg.Tylecote 1986:223). More recently systematic experimental production of iron by various ancient methods has yielded a more complete view of the total quantities of fuel used. These figures vary according to the type of furnace, ore, and secondary working of raw iron blooms carried out. To cite just one example here; Crew has produced an approximate figure of 100kg of charcoal and 25 total man/days required to produce a 1kg iron bar suitable for final forging into other artefacts using pre-Roman Iron Age methods in Wales (Crew 1991:35). Some medieval furnaces would probably have been substantially more efficient, especially with the application of waterpower in later medieval times (Cleere and Crossley et al 1995:111), but it is still clear that the volume of charcoal and labour used at each stage was huge.

We might cite one worked example here, lap rove nails of the heavily built Kingston No3 'boat' (or perhaps small ship) of around 1300 AD were very well preserved and had an average measured weight of about 80 grams including the nail and rove. This is just over twice the estimated weight of typical 10th century Scandinavian examples (Crumlin-Pedersen 1997:187). A representative square metre of Kingston No.3 hull would have had about 2.5 Kg of finished iron in it, representing perhaps between 0.12 to 0.20 tonne of charcoal or very roughly 0.5-1 tonnes of wood. Even if the vessel was only 15m long with a beam of 4m it would have needed at the very least 200kg of iron rove nails to build the basic hull alone, representing a minimum of perhaps 40 tons of wood fuel prior to conversion. The indirect impact of this demand must have been considerable in labour and woodmanship terms. Clearly this area demands more attention in future, both in terms of a wider review of experimental data and comparative calculations of raw materials consumed in the building of different archaeologically and historically known vessels.

With the adoption of carvel ship building in which treenail fastenings were widely used and iron much more sparingly for bolts at key locations such, as in fastening knees in the Mary Rose, there would clearly have been some savings in the use of iron. As iron production in the Weald area south of London did not decrease at this time we can suggest that the military imperative was channelling the surplus production in the new direction of cannons and other armaments instead of clinker ship nails by the tonne.

9/6 IN SUM. AND SOME POSSIBLE DEVELOPMENT OF LINES OF ENQUIRY DEVELOPED IN THIS STUDY

This study has eclectically borrowed from a number of related fields and built on some established lines of enquiry in nautical archaeology, to show changes in both the practice of boat and ship building and aspects of cultural landscapes from c. 900-1600 AD. However, it has also opened up other lines of enquiry which have only just been touched on. This concluding section attempts to summarise some of the trends revealed and outline possible areas of further research.

9/6/1 In sum

This study has thrown light on some relatively little explored facets of boat and ship building in England from the late Anglo-Saxon to early post-medieval periods. The joint foci have been;

Firstly, to explore the evidence for working practices, tools and methods used by boat and ship builders, professional and or part-time, and associated ancillary workers.

Secondly, to reconstruct the treeland resources used.

Chapter nine has attempted to provide a detailed synthesis of this work backing up the case studies and evidence presented in chapters 5, 6, and 7 and drawing on the other sources such as historical accounts, ethnographic evidence, the results of experimental reconstruction work and iconography alluded to in chapter 8. Insights gained into ship and boat building practice and changes there in, have been presented with descriptions of the techniques and tools evidenced in the material. This has been placed along side reasoned estimations of changing amounts and character of labour investment across the social spectrum and through time from c. 900-1600AD. The huge contrasts between the labour and technical investment required to build a late-Saxon simple dugout boat and a later medieval clinker river barge as against those required for a royal galley of the 13th century have been made above. These could be said to represent contrasts between the nautical expression of domestic peasant needs steeped in local tradition, the needs of merchants and towns folk operating at a regional level and the needs of the royal medieval military machine operating at a national and international level. The technical trends revealed take us from a situation of strong regionally distinct traditions such as the New Fresh Wharf style of construction from our early medieval period to the very much more international technical world of carvel shipbuilding in the 16th century. However, the archaeological evidence shows that at the vernacular level there were strong continuities in practice as well as clear changes. Whilst a Saxon treewright of 10th century Lundenburgh might find the sawn oak and elm planks and copper nails of a Thames side clinker boatbuilder of c. 1900 strange he would have understood the basic building proceedure easily enough. The same could not be said of some masters of carvel shipbuilding, perhaps as early as the end of the 16th century.

Insights gained into the selection of specific types and species of timber used by boat and ship builders over the 700 year study period, have been presented in text and graphics. The trends in changing treescapes are both strong and subtle but clearly represent only part of the picture and must eventually be set besides studies of other types of evidence for the period and region such as studies of charcoal, roundwood and strictly localised pollen sequencies. However, we can see the complex mosaic of treeland types of the 10th century which included the great trees of the wildwood (or wildwood type woodland) in the London hinterland changed into a tightly managed set of domesticated treeland forms by the mid 13th century which lacked the wildwood. Foreign wildwoods were then exploited for high quality ship board, first the Irish temperate rain forest and then the inner continental woods of the SE Baltic region. The harvesting of distant wildwoods still continues today in some forms of wooden boatbuilding despite evidence that in the 16th century that increasingly large carvel vessels could be built out of native trees of moderate quality and size.

It is hoped that the imbededness of medieval ship and boat building as an economic and technical activity in particular land settings has been demonstrated. Perhaps this may help to link sometimes peripheral nautical archaeology closer to central concerns of main stream archaeology such, as landscape change and how natural resources were moulded and exploited through technology and labour in the medieval past.

9/6/2 Some specific suggestions for future work

A few possible areas for productive future research which could flow from this study are annotated below;

a/ The changing technology of post-medieval shipwrightry and boat building at the practice level up to the 'vernacular threshold' of the mid 19th to late century.

b/ The myths of timber supply for post-medieval to 19th century British shipbuilding, and our historic wooded landscapes.

c/ A thorough re-assessment of the medieval ship and boat building documentary accounts, informed by recent archaeological, tree-ring and other work. A collaborative work with a skilled medieval historian who can read the original documents.

d/ The nature of medieval English boat and ship framing, materials and systems in relation to building sequences.

e/ The economics and environmental implications of iron use in boat and ship building.

f/ The character of large timber trees in Britain from prehistoric to post-medieval times, including those of areas now tree-less. Based on reconstructing parent trees for more complete dugout boat finds, bog trees and other large structural timbers. This would enable us to see the giants of the extinct British wildwood and wildwood type woodland, now a key aim of some historical ecologists of woodland.

g/ The development of regional styles in British vernacular boatbuilding, at the level of practice and materials rather than just hull form, rig and function.

h/ The correlations of broad patterns of changes in techniques of craft practice and raw materials used in Medieval SE England with similar developments in continental Europe and Scandinavia.

I/ Searching for living correlates to the hypothetical parent trees reconstructed for this study and documenting them photographically as done by Rival for several classical Mediterranean ship finds (Rival 1991). These photographs could then be used to illustrate more accessible summaries of parts of this study.

J/ To finish the Kentmere extended dugout boat reconstruction and compile a monograph on this previously poorly understood find.

ACKNOWLEDGEMENTS

None of the following are responsible for errors of style, format or content which this thesis contains but all have contributed in various ways over the years. Thanks are due to G. Milne for encouragement and assistance over many years. They are also due to Professor J Graham-Campbell who provided much useful comment. Thanks are also due to others not directly involved in the thesis but who have provided encouragement or assistance in other ways. V. Fenwick helped initiate the writer into the subdiscipline of boat archaeology. J. Norman provided easy access to ancient woodland on the edge of London for much of the experimental work, and donated several trees as well as providing comment on treeland reconstructions. R. Darrah has provided comments and training in some practical aspects of early woodworking. I. Tyers also provided useful discussion of issues relating to tree-ring research.

Particular thanks are due to O. Crumlin-Pedersen, J. Bill, A. Englert and others at the Roskilde Maritime Archaeology Research Centre, the Viking Ship Museum at Roskilde, and the Museum Shipyard who have provided thought provoking discussion of aspects of this work and help tracking down references etc. Thanks are also due to the same centre for providing support for a weeks study visit during the reworking of the first submitted draft.

Open ended thanks are due to many researchers of many nationalities who have spared time to discuss issues covered by this study at symposia (particularly ISBSA) and seminars over the last few years, particularly AE Christensen, J. Adams, C. Dobbs, C. Westerdahl, B. Arnold and A. Van de Moortel.

Thanks are due to the Museum of London for providing some support for this part time study in the early years and tolerance later on. Thanks are also due to G. Hutchinson of the National Maritime Museum for providing access to the Kentmere boat timbers held in store.

Finally, thanks are also due to the writers family for putting up with bouts of practical work at anti-social times, and a lack of due parental and husbandly attention during the compilation of these 2 volumes and earlier drafts. Unfortunately it is not possible to convey thanks to my father who started my interest in wooden boats from the age of 3 and bought me a copy of the Archaeology of The Boat by B Greenhill which set things in motion, as he died prematurely during the editing of this text whilst working on his boat.

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Abbreviations used

Antiq. for Antiquity.
Archeol Jnl. for Archaeological Journal
IJNA. for International Journal of Nautical Archaeology.
BAR. for British Archaeological Reports.
CBA. for Council for British Archaeology.
WARP. for Wetland Archaeological Research Project.
EH. for English Heritage.
MM. for Mariners Mirror.
Med.Arch. for Medieval Archaeology.
HMSO. for Her Majesties Stationary Office.
LA. for London Archaeologist.
Trans. LAMAS for Transactions of the London and Middlesex archaeology Society.
NMM for National Maritime Museum Greenwich.
MoL for Museum of London.
RCHM for Royal Commission for Historic Monuments
ISBSA for International Symposium on Boat and Ship Archaeology

NB Where reference has been made to papers in a collected work such as a conference proceedings, the publication is listed as author, year, title, the editor(s) year and page numbers, as is the practice in many British archaeological journals.

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AN ARCHAEOLOGY OF EARLY ENGLISH BOATBUILDING PRACTICE c.900-1600 AD:

Based mainly on finds from SE England

VOLUME 2. FIGURES AND APPENDICES

(Appendices and supporting papers in rear pocket)

For a PhD in Archaeology at the Dept. of Medieval Archaeology, Institute of Archaeology UCL. London.

Re-submitted November 2002

DM Goodburn

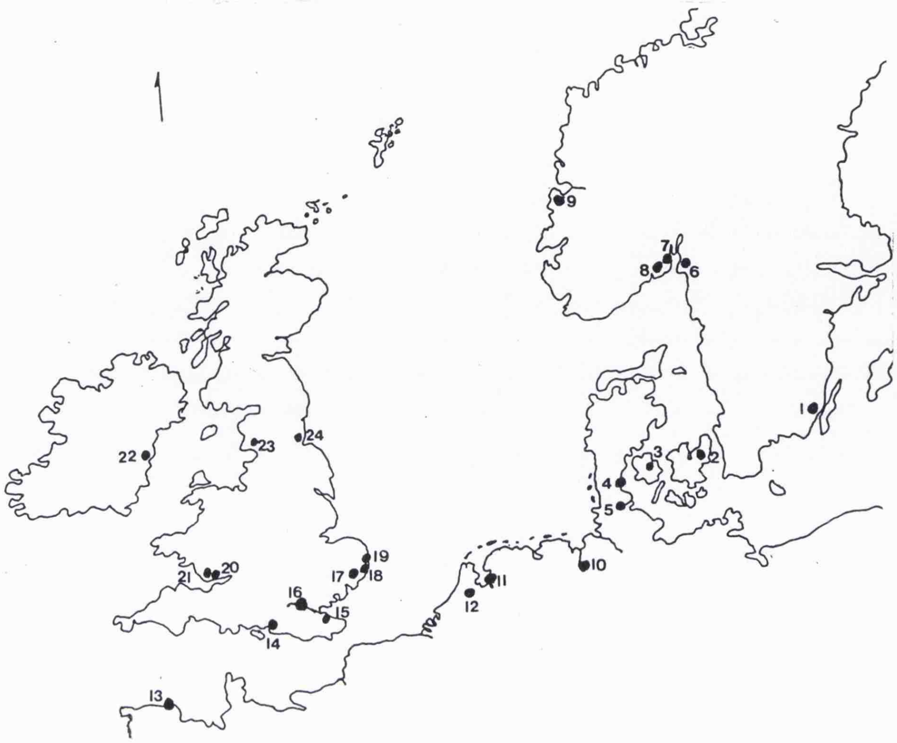


FIGURE 1 CAPTION.

Fig. 1 Map showing find spots of key vessels and vessel groups noted in the historical survey chapt.2 (updated in Apendix 13). 1) Kalmar, 2) Skuldelev 3) Ladby, 4) Egernsund, 5) Schleswig-Hedeby, 6) Tune, 7) Oseberg, 8) Gokstad, 9) Bryggen, 10) Bremen, 11) Ijsselmeer, 12) Utrecht, 13) Aber Wrac'h, 14) Hamble, 15) Graveney, 16) Greater London, 17) Sutton Hoo, 18) Snape, 19) Ashby Dell, 20) Magor Pill, 21) Newport, 22) Dublin, 23) Kentmere, 24) Hartlepool.

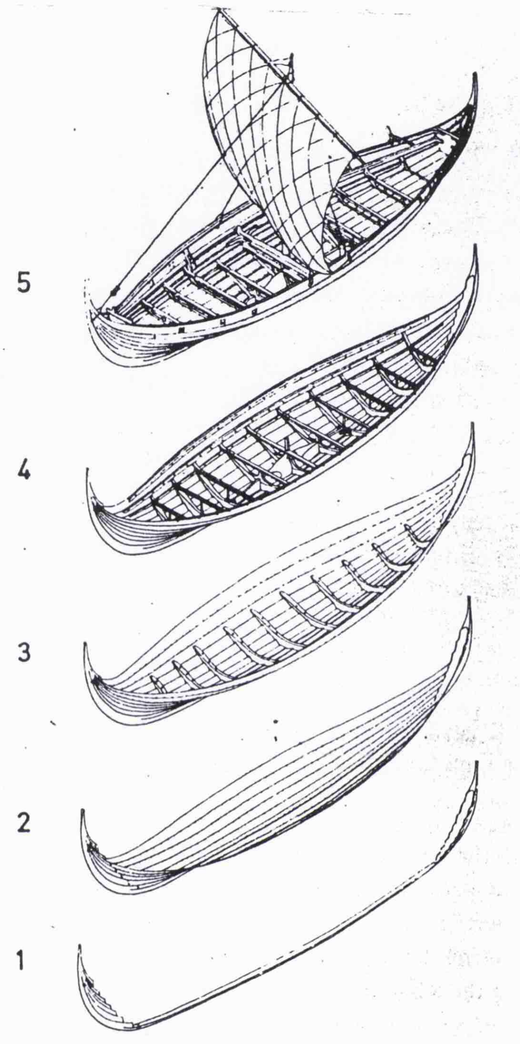


Fig. 2 The sequence of building an early medieval Scandinavian clinker vessel, Skuldelev 3, after Olsen and Crumlin-Pedersen 1978.

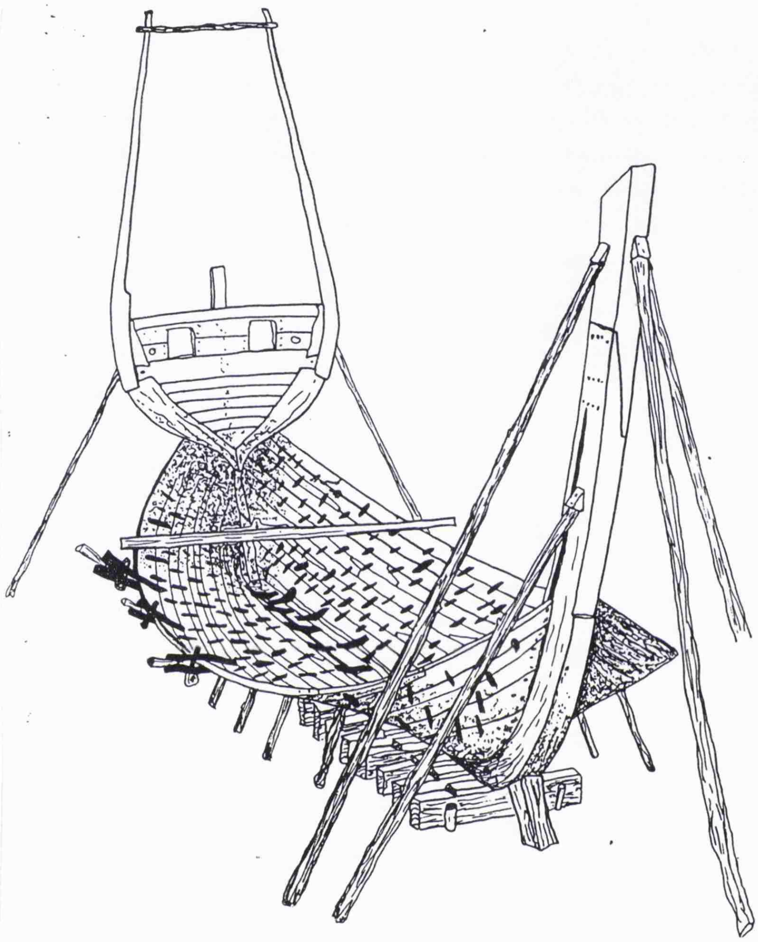


Fig. 3 A sketch showing shell-first carvel construction, redrawn from Landstrom 1974.

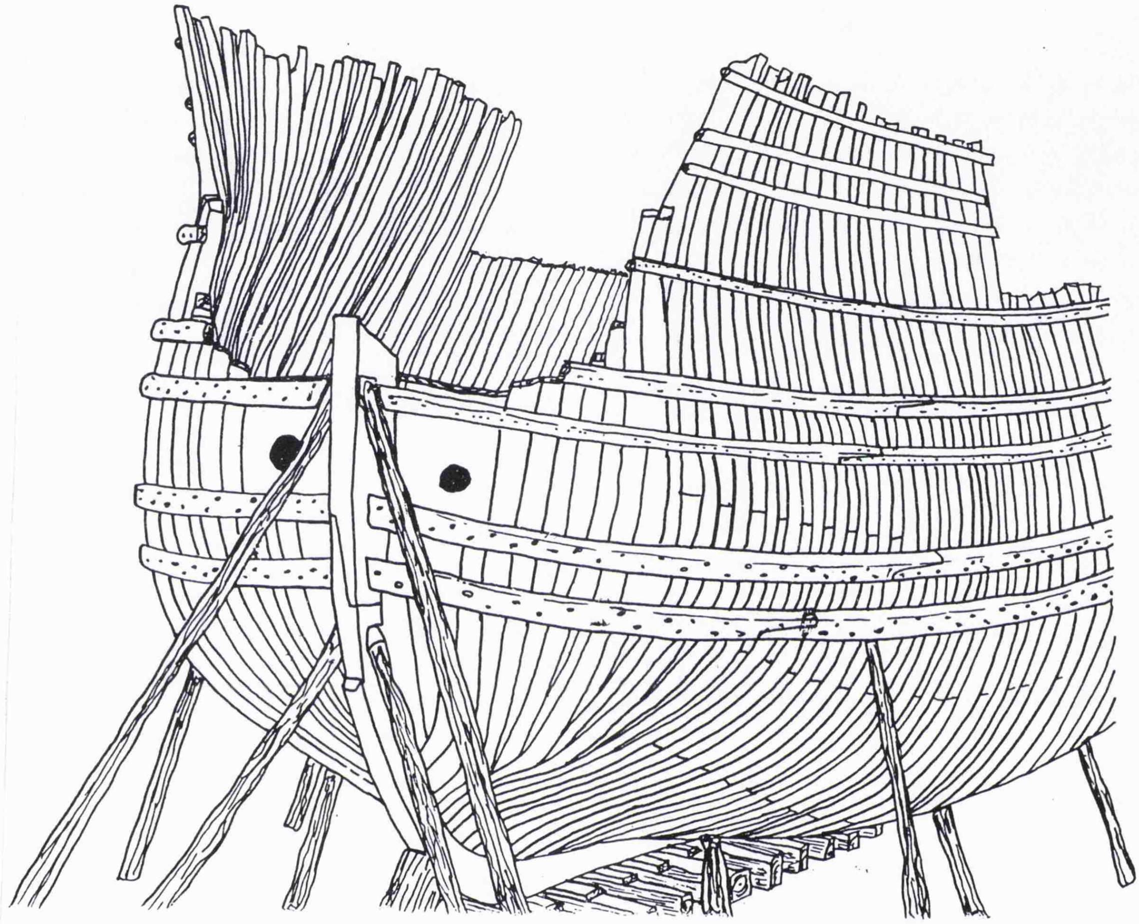


Fig. 4 A sketch showing frame-first carvel construction, redrawn from Landstrom 1974.

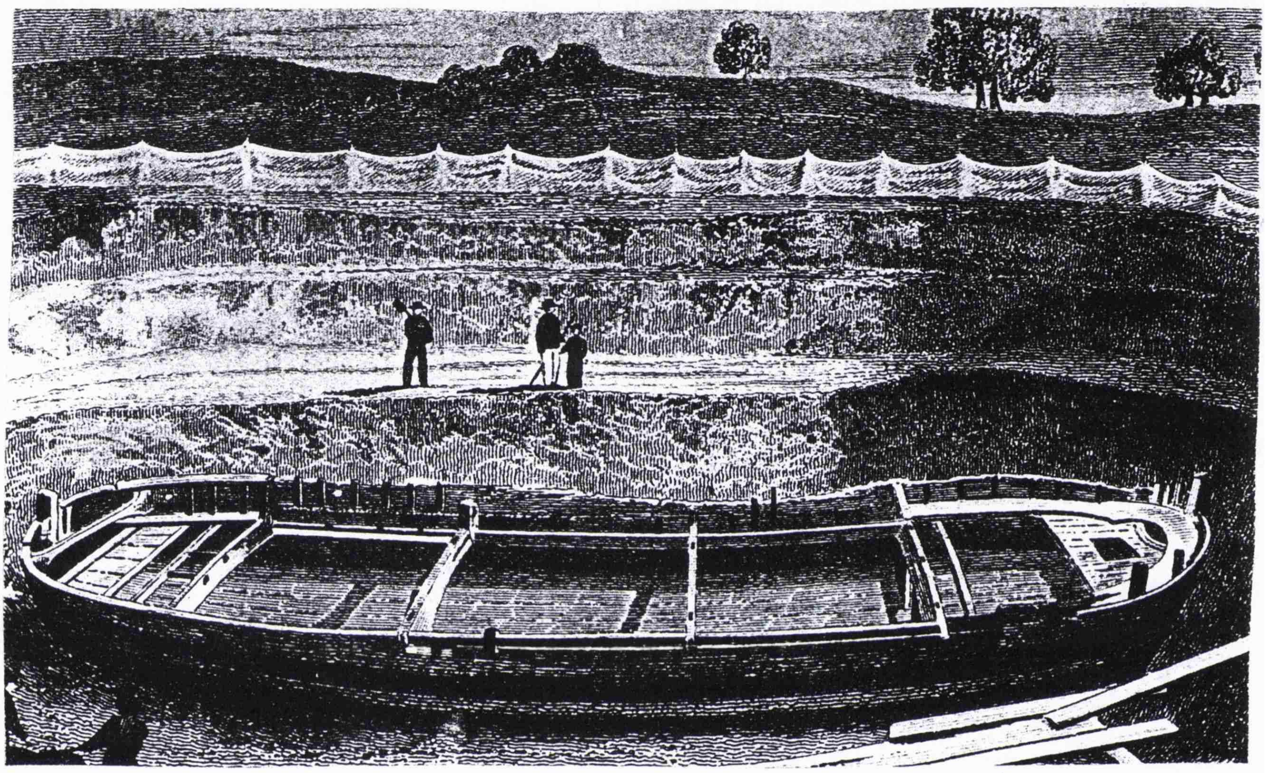


Fig. 5 The probably 16th century Rother vessel of possible low countries origin, after Phillips-Birt 1979.

2

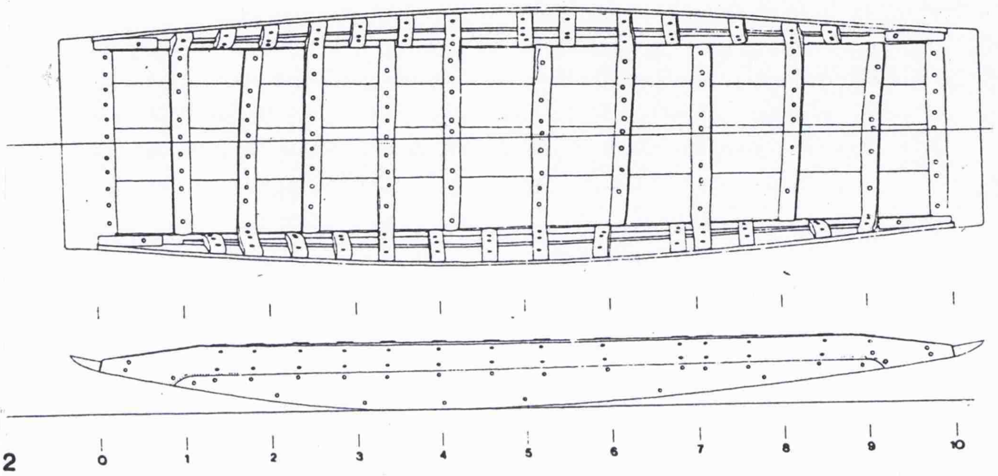


Fig. 6 The 12th century Egernsund barge after, Crumlin-Pedersen 1997.

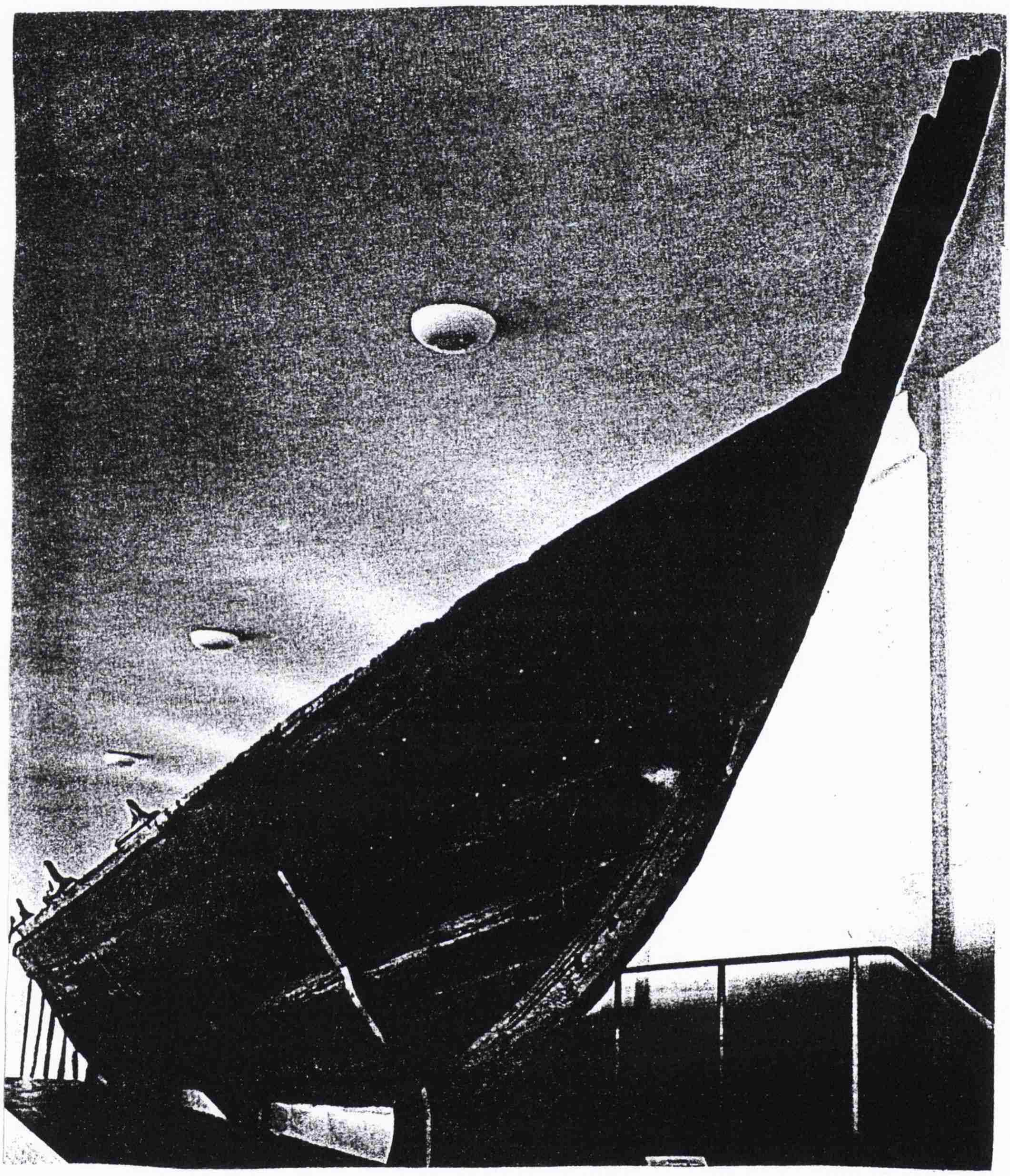


Fig. 7 The Nydam boat as restored, photo.

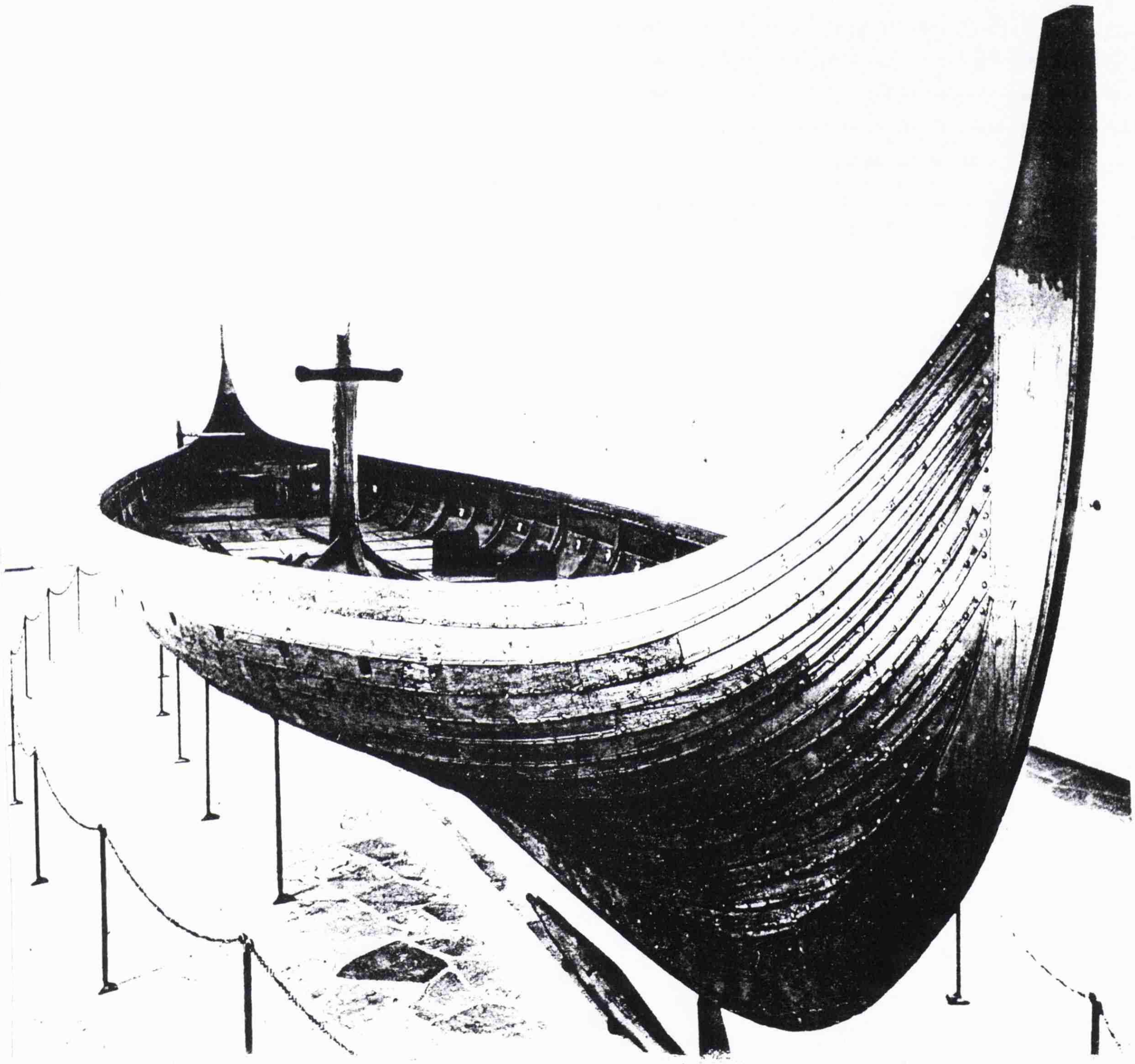


Fig. 8 The Gokstad ship as restored, photo after Sjovold 1985.

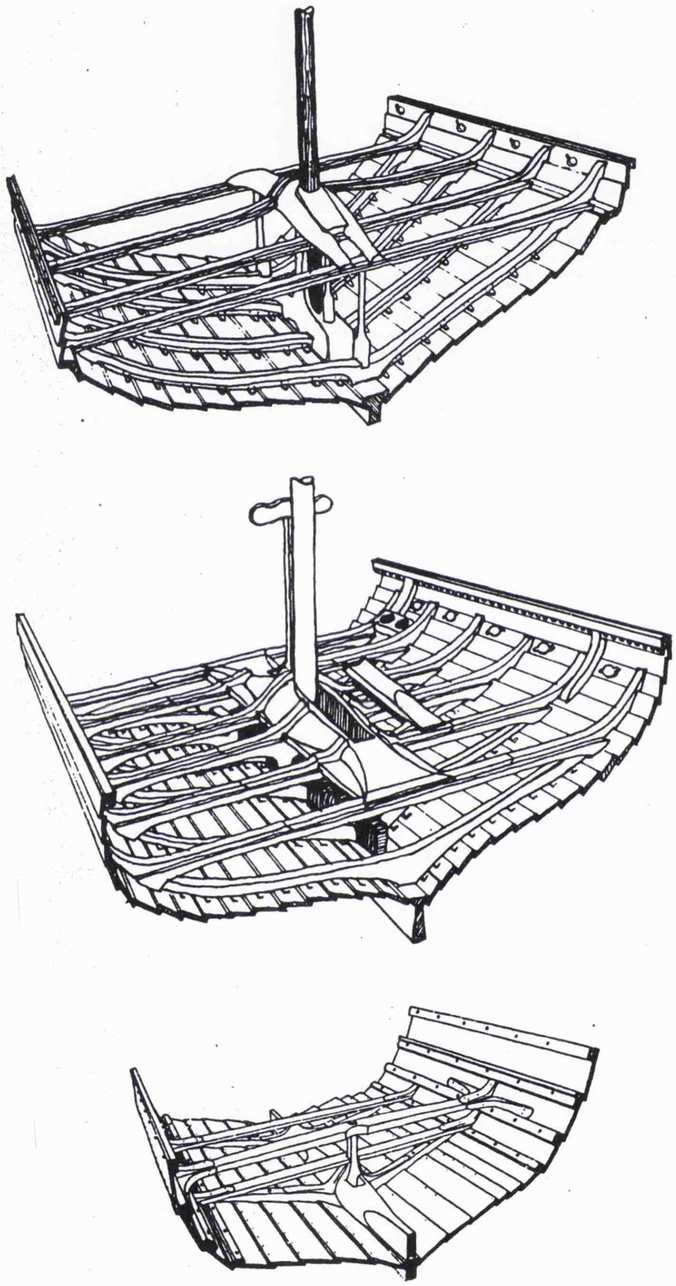


Fig. 9 Three Viking ship cross sections, Oseberg, Gokstad, and Skuldelev 3, after Greenhill 1976, (derived from drawings by Crumlin-Pedersen).

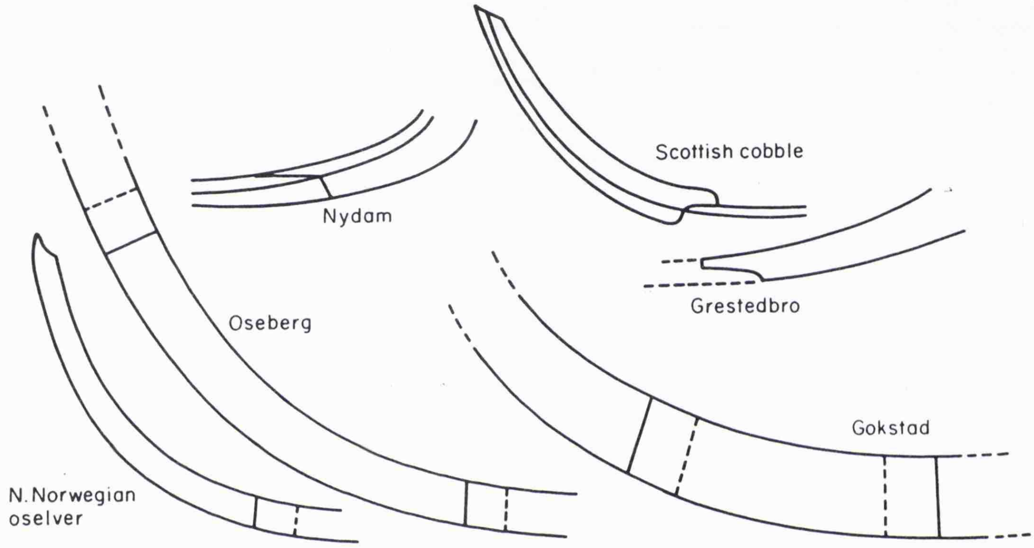


Fig. 10 Keel and stem scarfs in early medieval ships and modern vernacular boats, after Goodburn 1986.

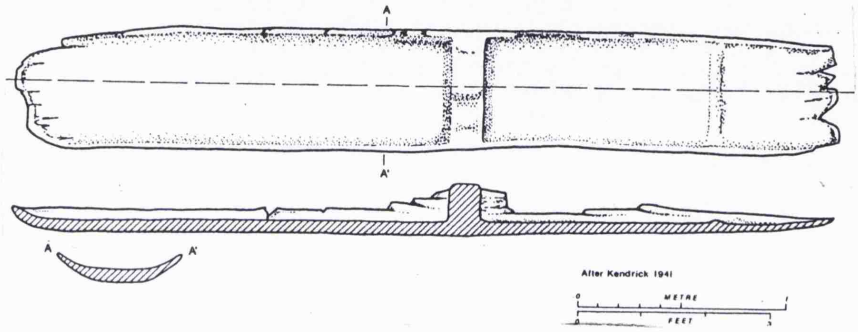


Fig. 11 The Walthamstow dugout boat after, McGrail 1978.

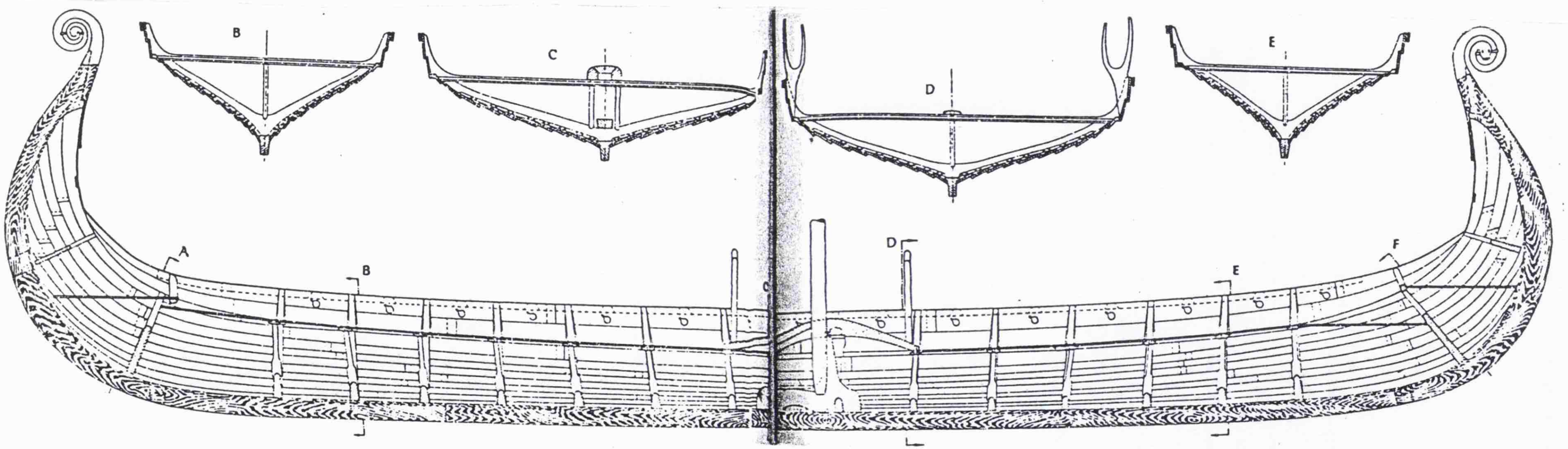


Fig. 12 The 9th century Oseberg ship, after Phillips-Birt 1979.

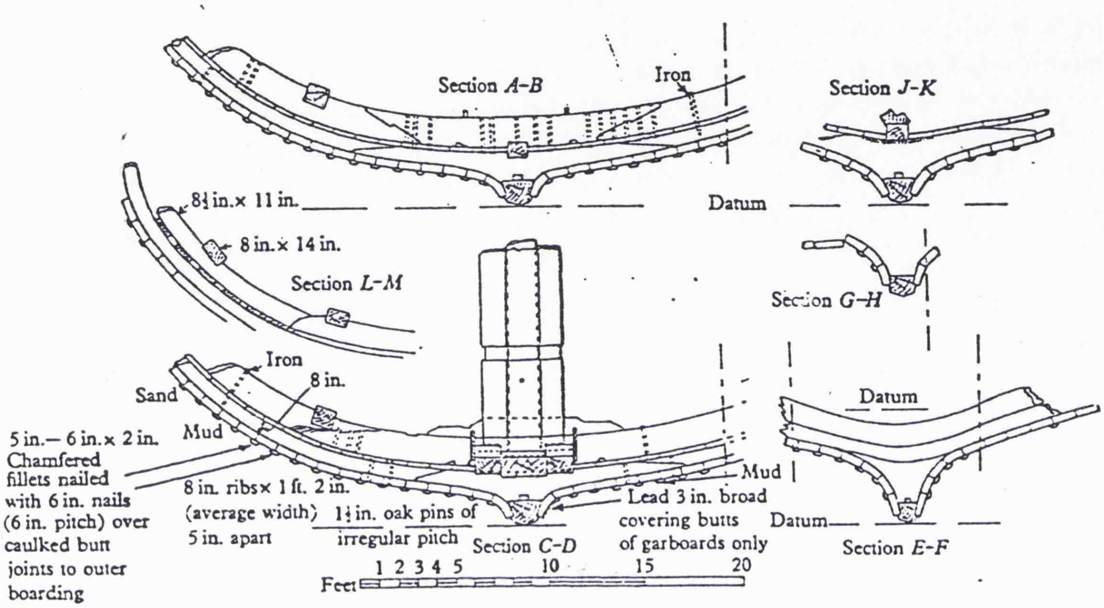


Fig. 13 The c. 16th century Woolwich ship, details drawn by London County Council Surveyors.

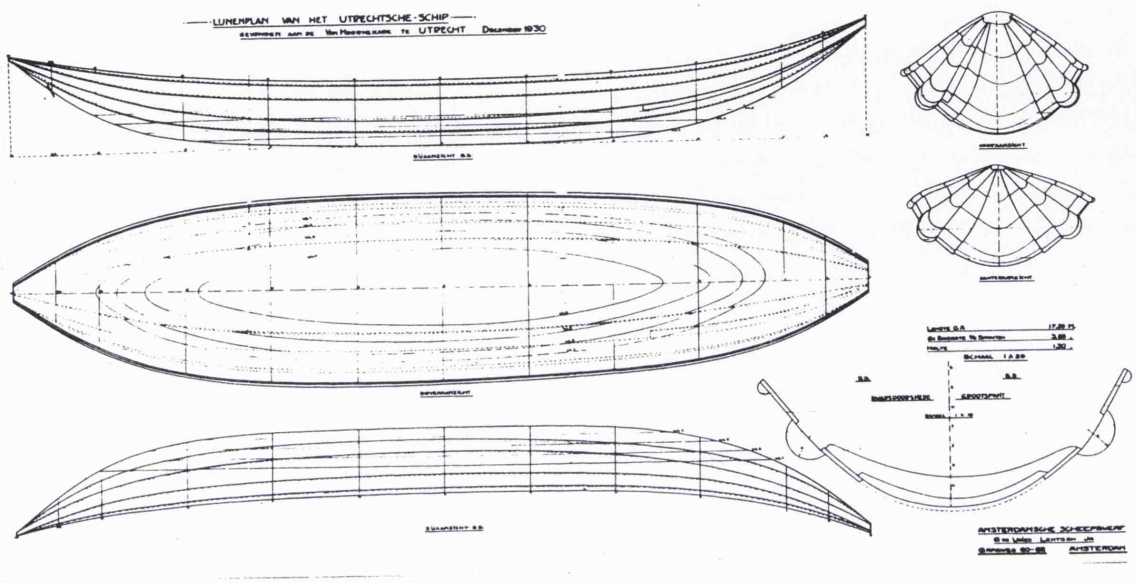


Fig. 14 The c. 11th century Utrecht ship, a hulc, after de Vries 1930.

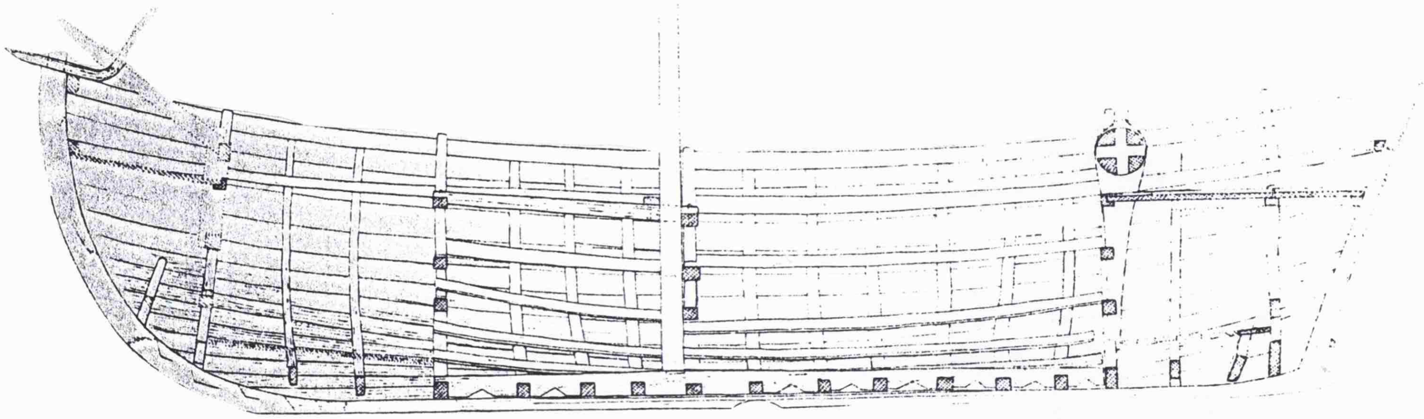


Fig. 15 The Kalmar 1 coastal trader, after Akerlund 1951.

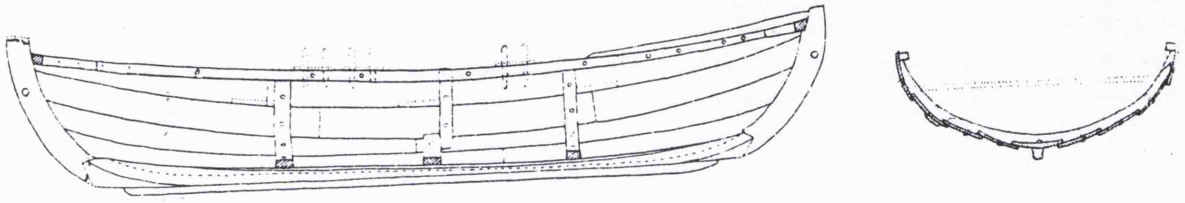


Fig. 16 The Kalmar 3 boat, after Akerlund 1951.

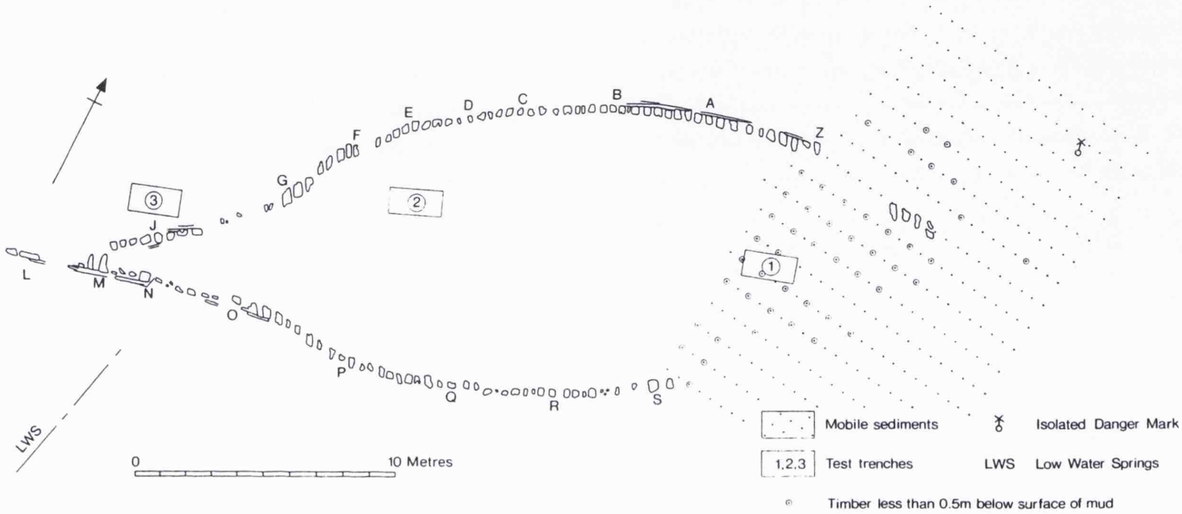


Fig. 17 Plan showing the exposed eroded frame ends of the 15th century Hamble river wreck, a large clinker warship, after NMM 1993 (In Hutchinson 1994a).

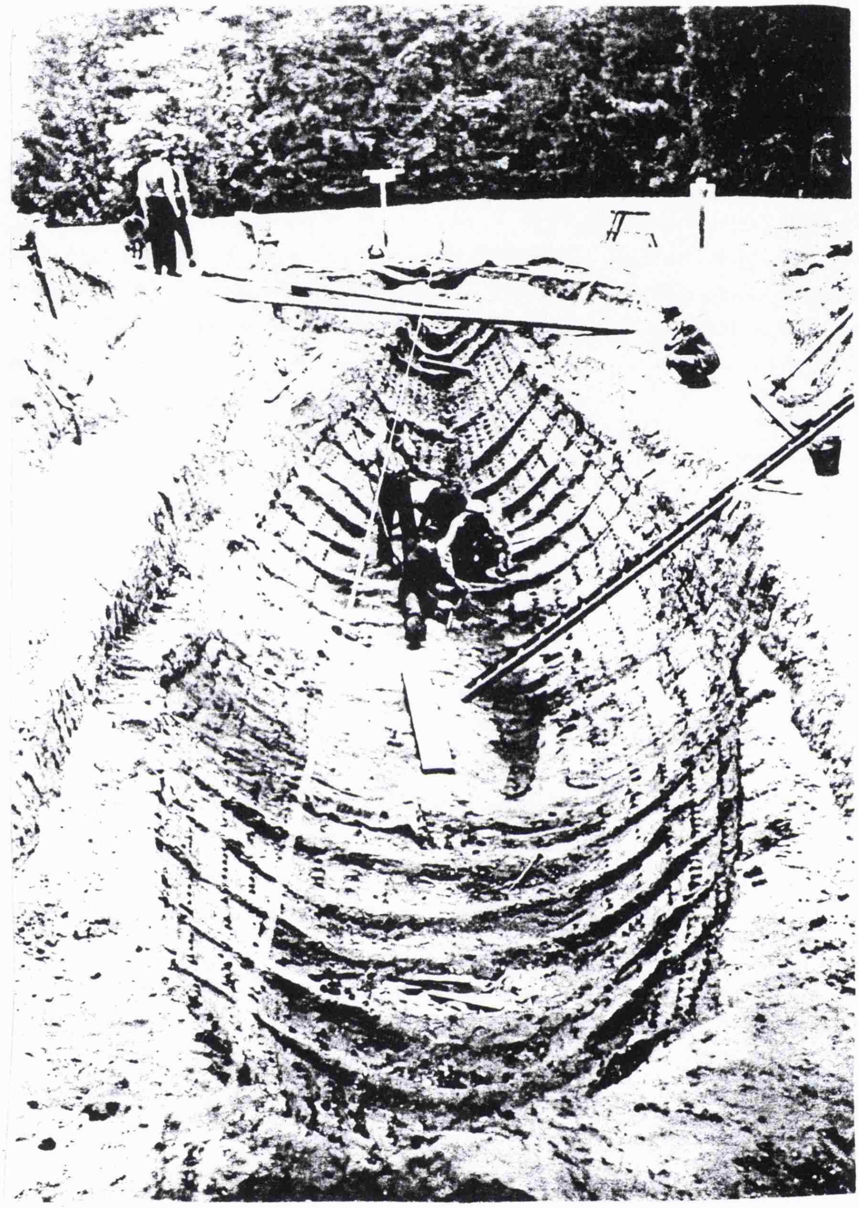


Fig. 18 The 7th century AD Sutton Hoo ship impression under excavation in 1939, photo NMM.

Fig. 19 The c. 14th century Kentmere 1 extended dugout boat in situ, Photo, NMM (in McGrail 1981).

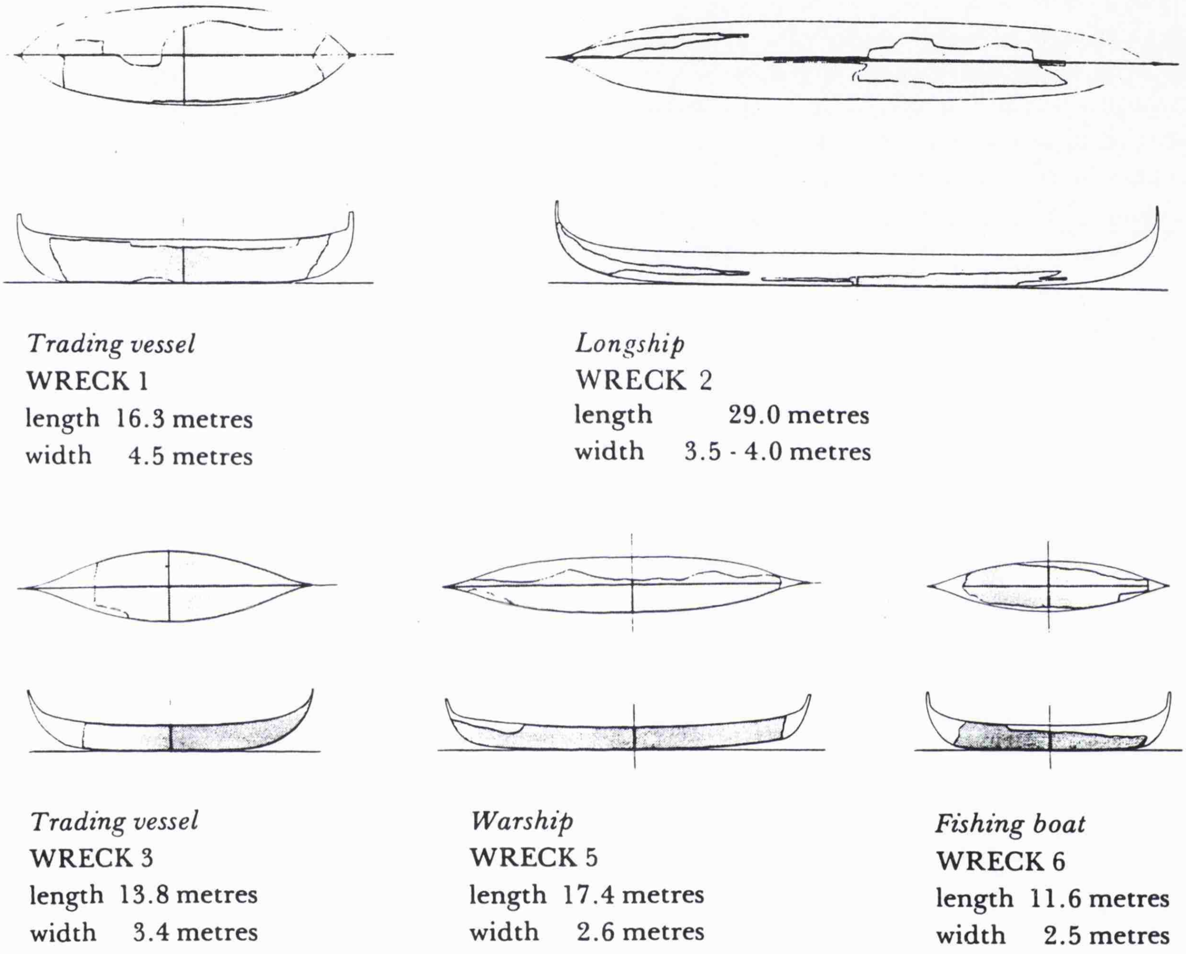
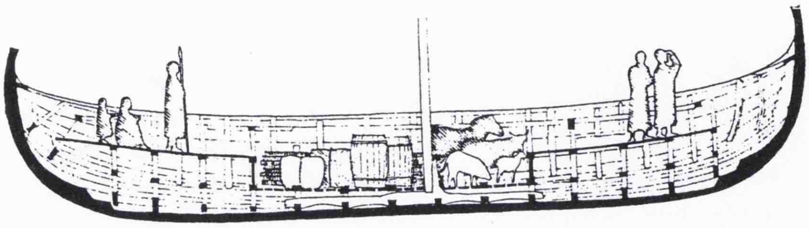


Fig. 20 The late Viking period Skuldelev vessels, after Olsen and Crumlin-Pedersen 1978.



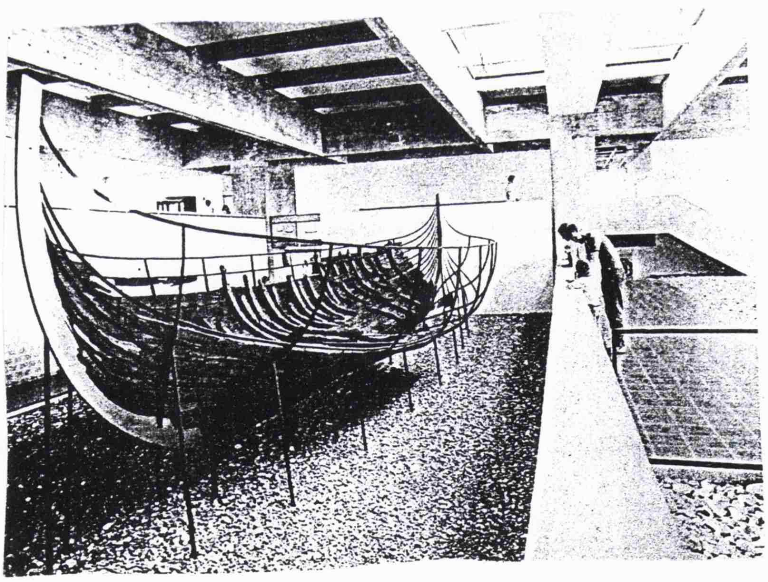


Fig. 21 The large late Viking trading vessel Skuldelev 1, Top, reconstructed elevation, Bottom, photo. of her displayed, after Olsen and Crumlin-Pedersen 1978.

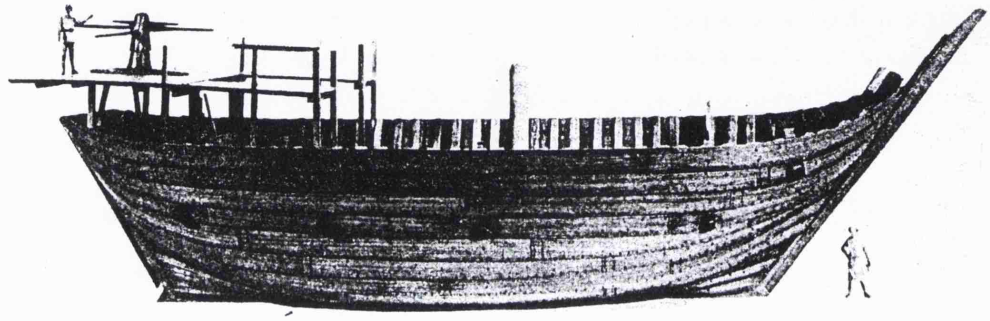


Fig. 22 Model of the 14th century Bremen cog, photo. after Greenhill 1976.

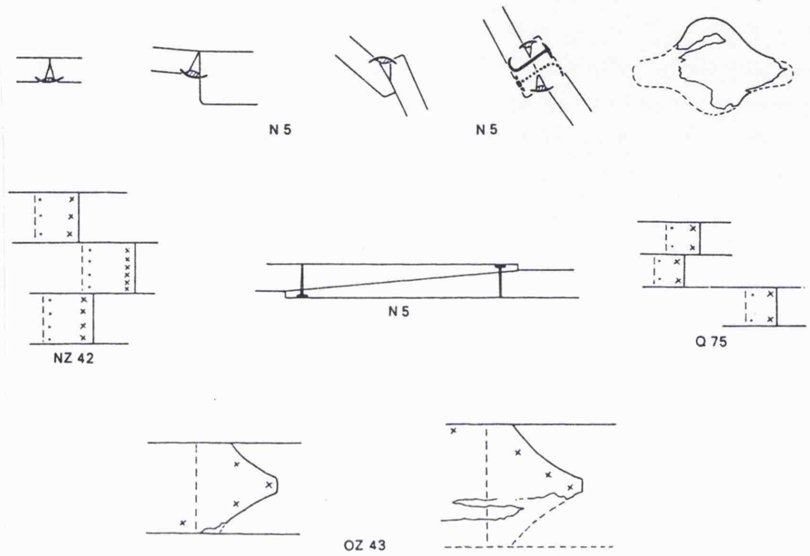


Fig. 23 Details of cog construction after Reinders 1985.

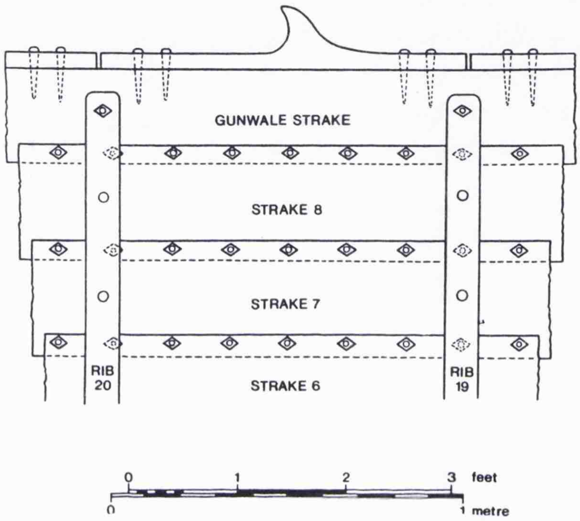


Fig. 24 Diagram of part of the Sutton Hoo ships side, after NMM 1972.
(In Care-Evans 1972).

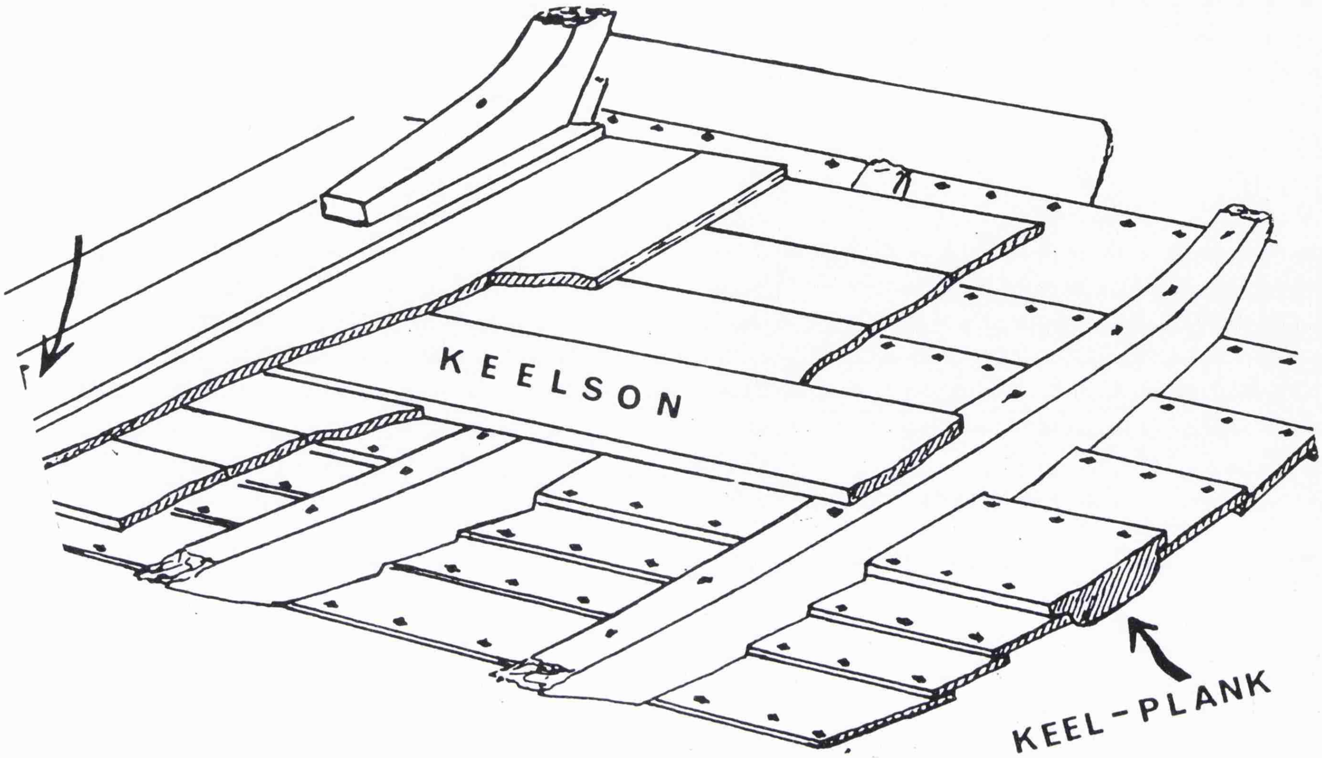


Fig. 25 Diagram of the construction of the 17th century Blackfriars 2 wreck, with strange softwood strengthening timbers, after Marsden 1972.

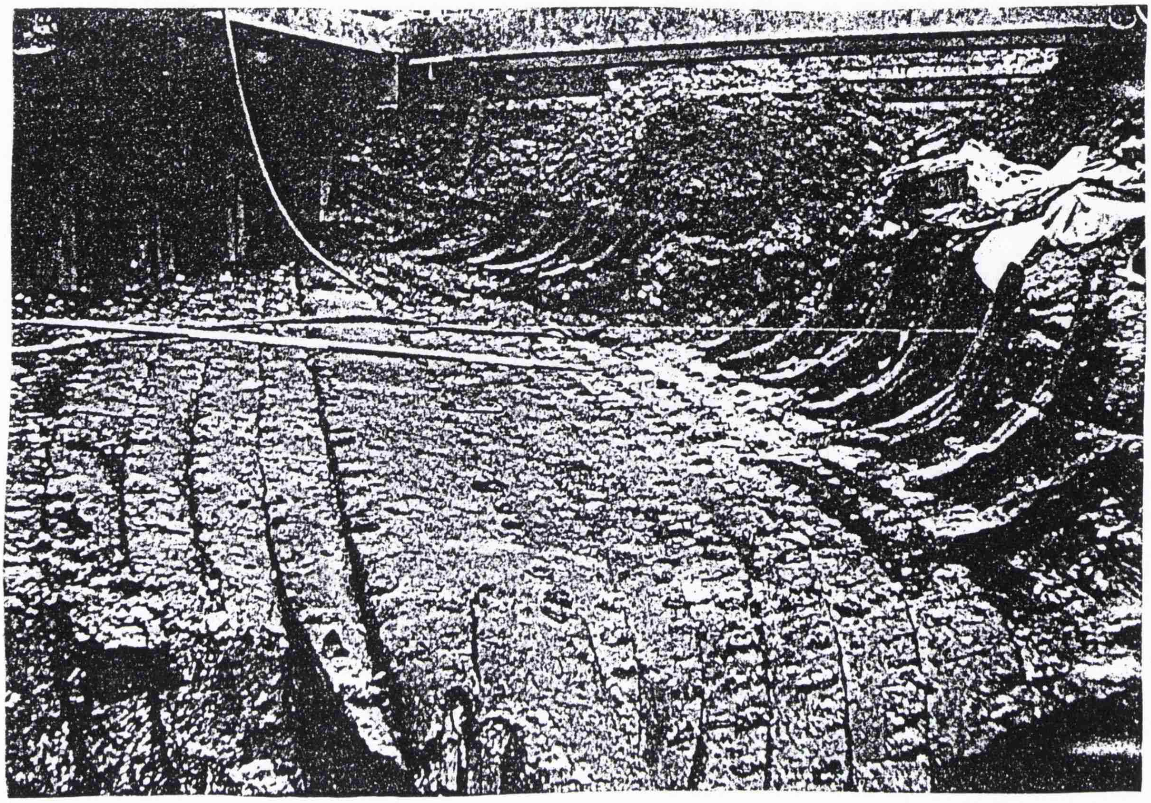
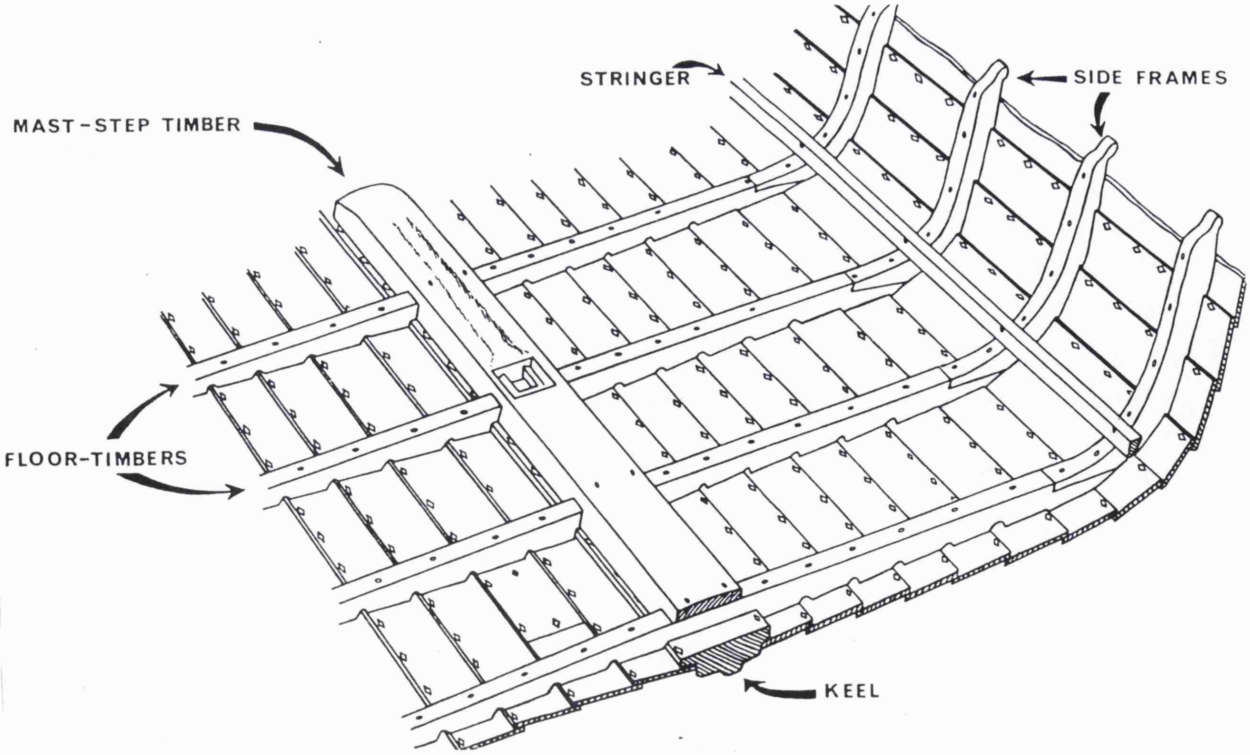


Fig. 26 The 14th century clinker river barge, a probable 'showt' Blackfriars 3 . Photo top in situ with floor framing removed. Bottom, diagram showing constructional layout, after Marsden 1972.



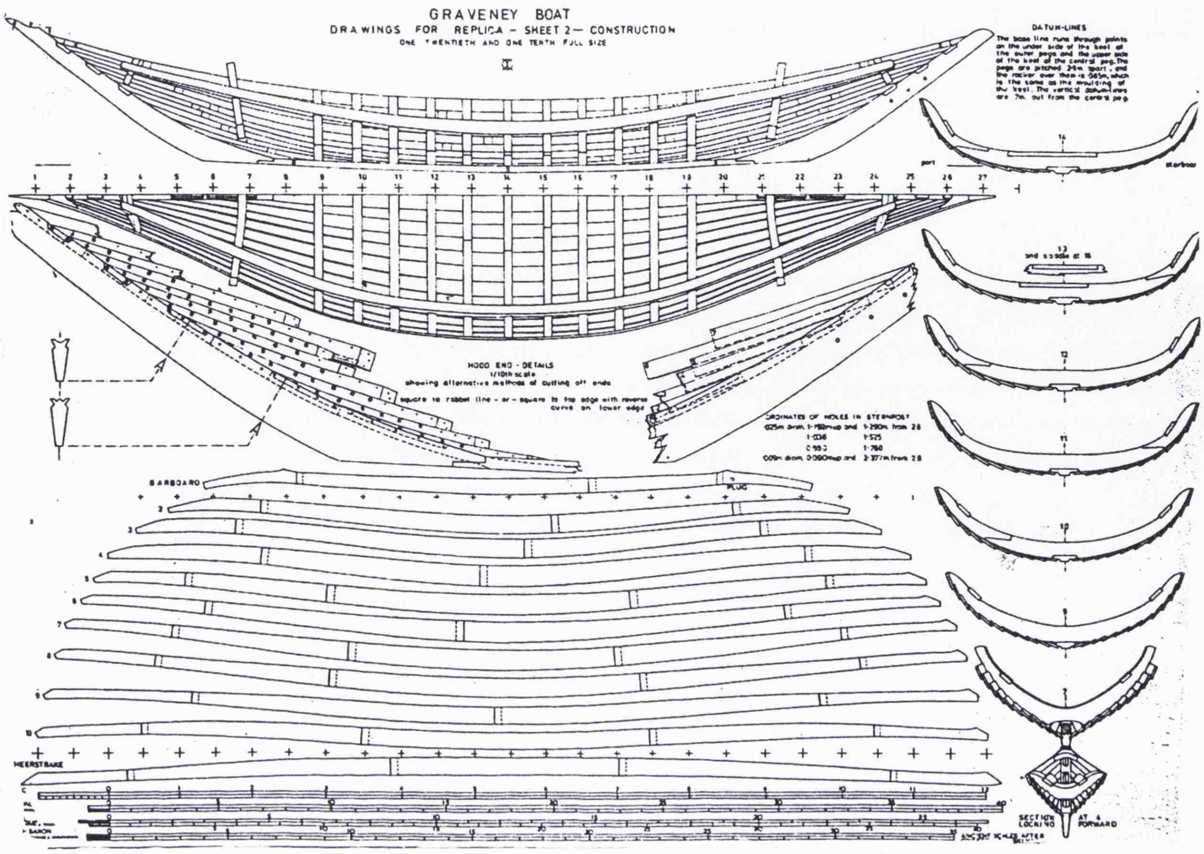
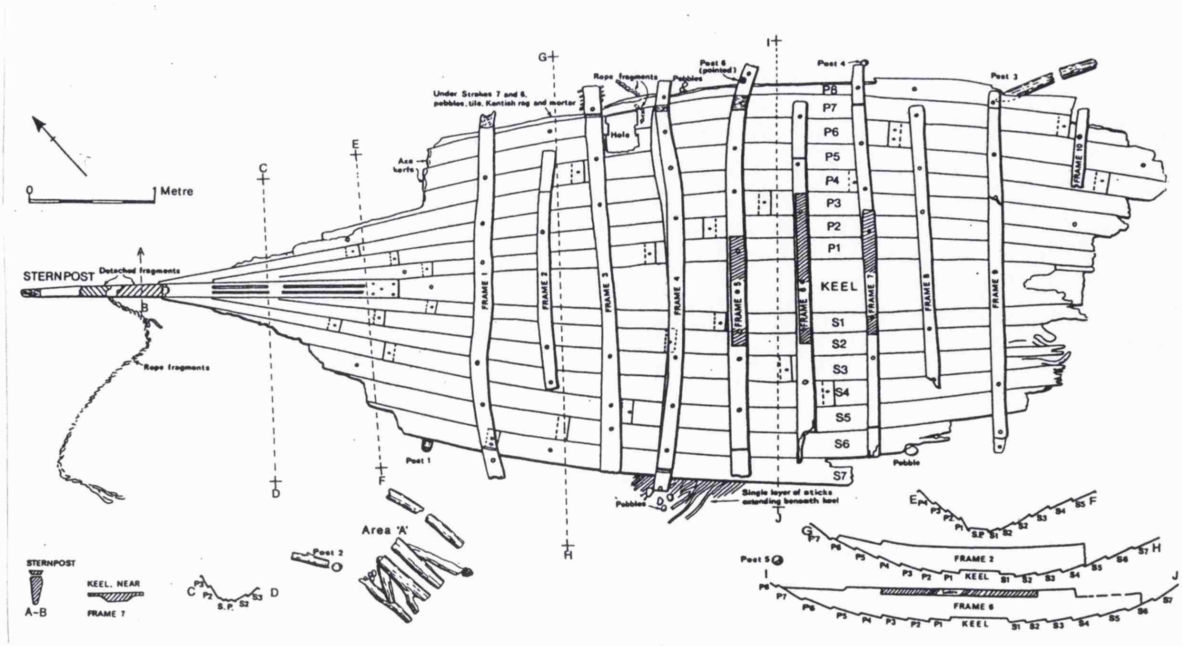


Fig. 27 The c. 10th century Graveney boat. Top, as reconstructed by Mckee . Bottom, plan of vessel in situ, after Fenwick ed. 1978.



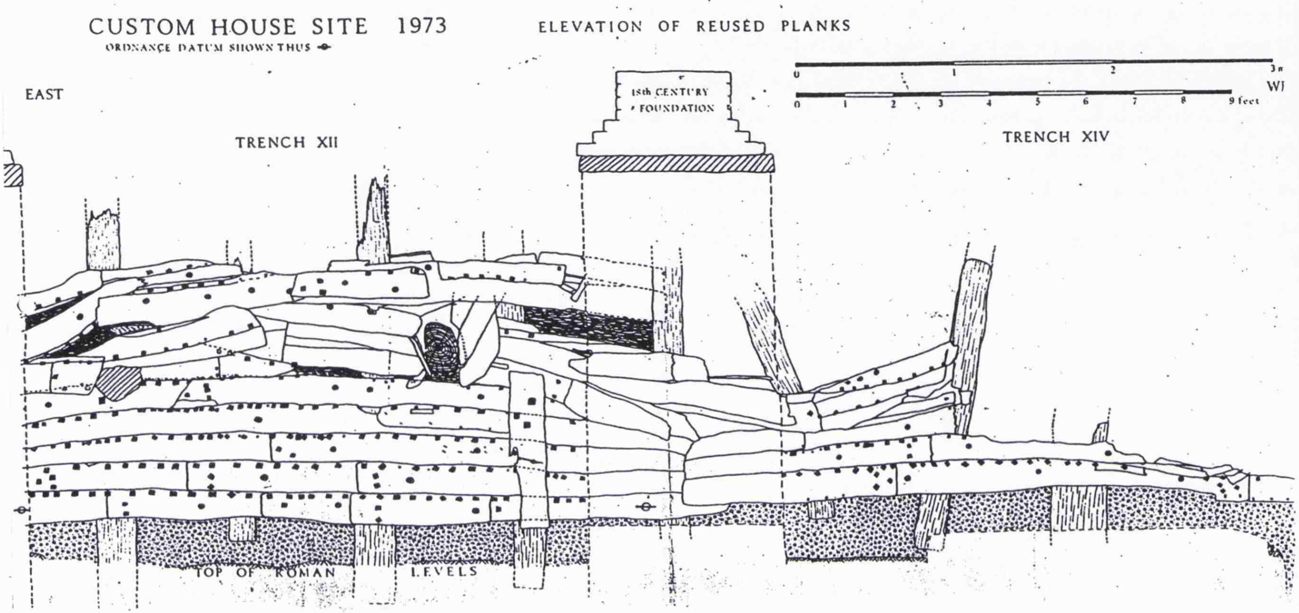


Fig. 28 The 12th century Customs House boat reused in two flattened slabs in a London river wall. After Tatton-Brown 1974.

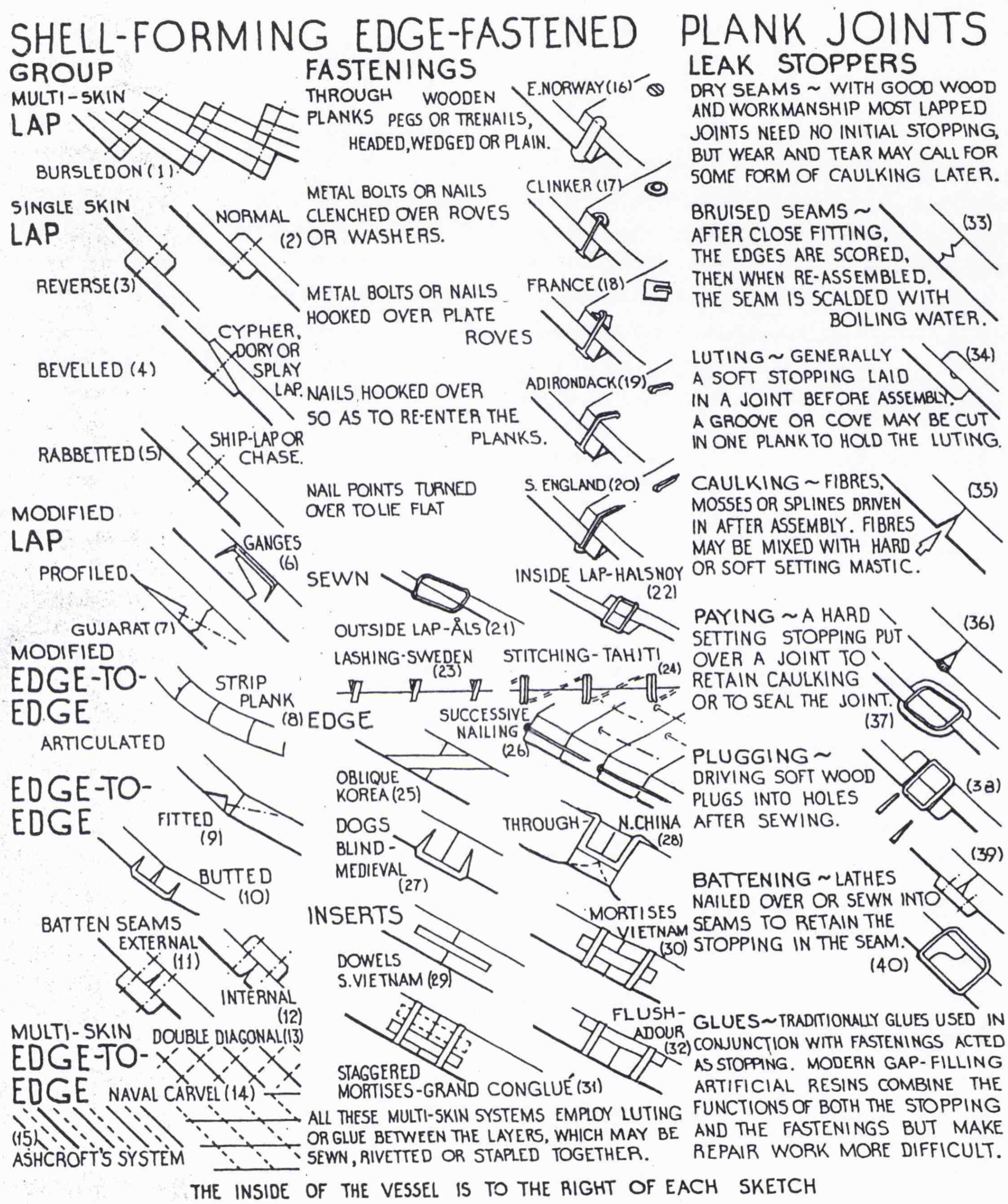


Fig. 29 Various hull plank edge fastening methods, after Mckee 1976.

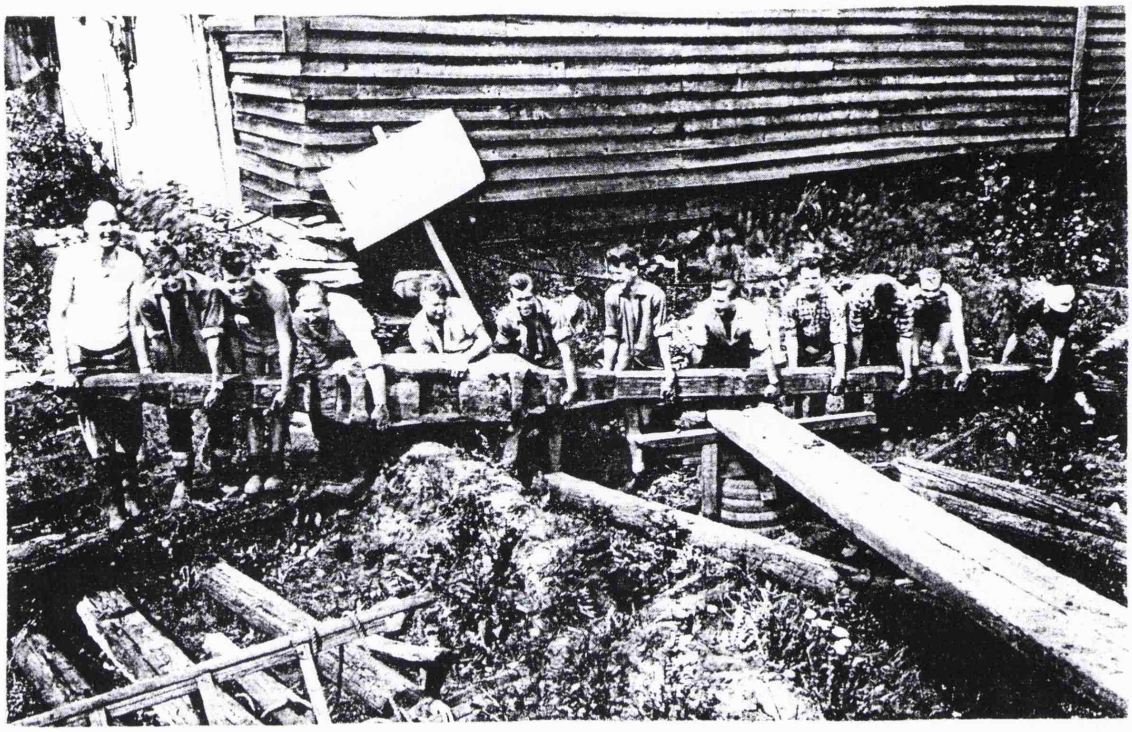


Fig. 30 Carrying out the Bryggen 'Big ship' keelson from excavations in Bergens Hansa quarter, photo after Christensen 1985.

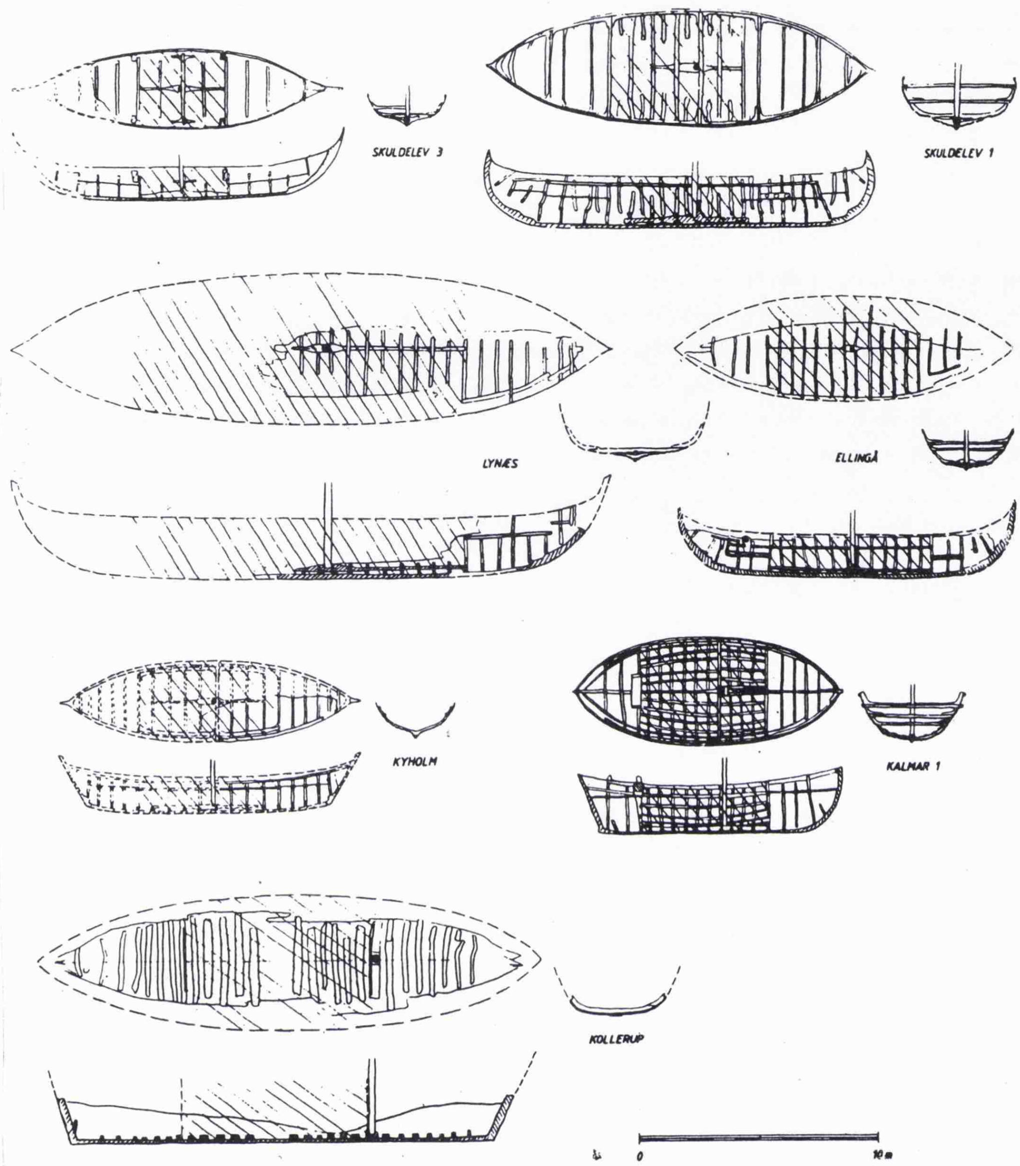


Fig. 31 Comparative outlines with cargo space shaded of various medieval vessels in the keel and cog tradition, after Crumlin-Pedersen 1983.

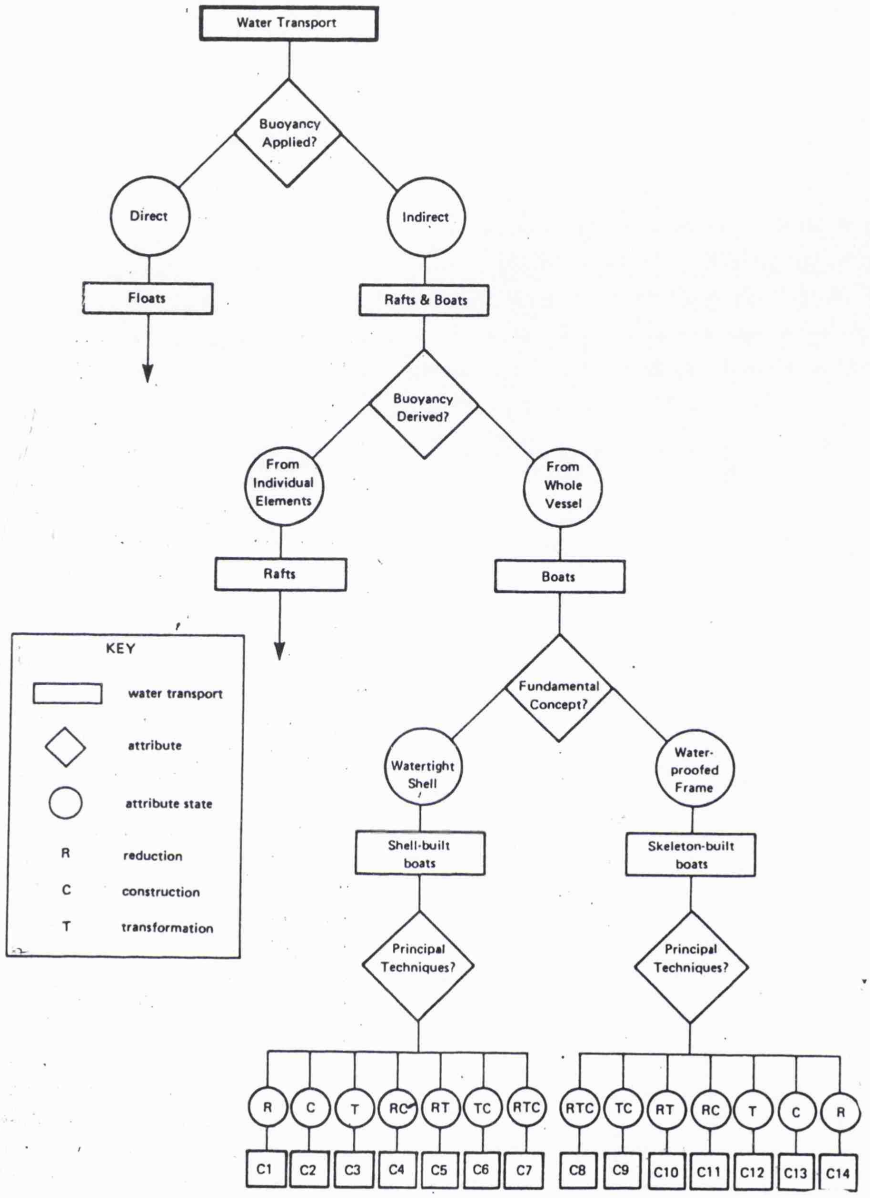


Fig. 32 Diagram to illustrated a classification system for boat finds, after McGrail 1987.

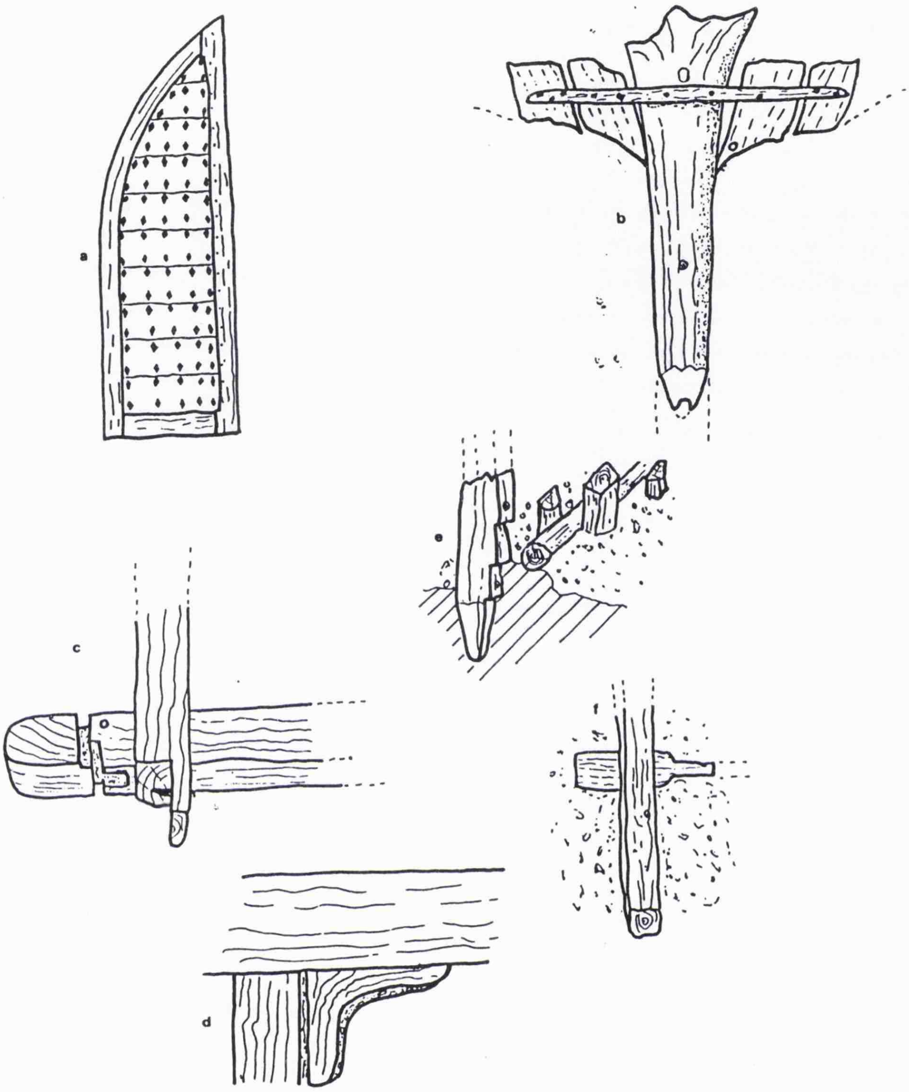


Fig. 33 Sketches of building timbers with nautical features or origins. A) Half a C15th door from Norwich Cathedral after Hewett 1985 . B) C10th arcade post and arch filling planking with Graveney style rove nails from Vintners Place, London. C) Corner joint in medieval building sill beam, the lower timber was a ship head beam, Bryggen after Christensen 1985. D) Ship knee timber as commonly reused in C18th buildings at Chatham and Portsmouth Naval dockyards. E) Late-Saxon Clinker boat frame timber reused in a probable wall foundation at Bull Wharf. F) Pre-Conquest oar or paddle blade reused as a bearer under a floor joist at Bull Wharf.

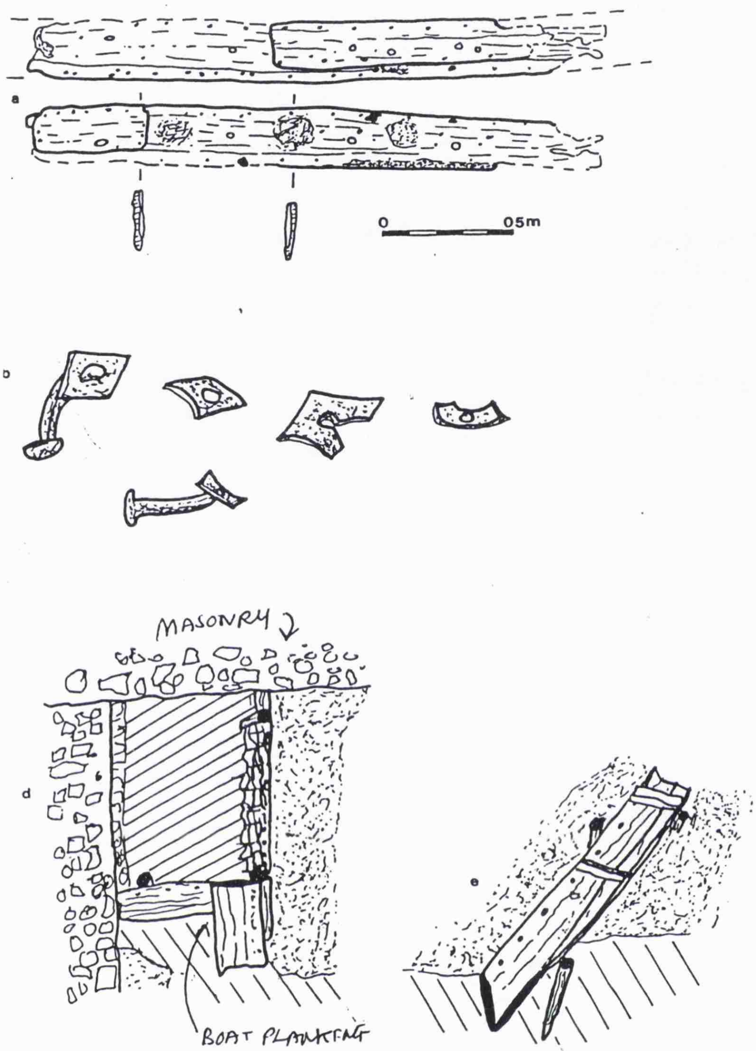


Fig. 34 Sketches showing- A) A reused medieval clinker boat plank from, Kingston Horsefair No. 1 boat, with a repair patch made from an old clinker boat plank in which the redundant treenail holes are clearly visible. B) The distorted shapes of Late-Saxon period roves and rove nails as found in foreshore deposits at Vintners Place. C) Viking iron claw-drift tool from Gotland, used for driving off roves during the break up or repair of riveted vessels, after McGrail 1987. D) Medieval pit lining from the Fleet Valley area 3 excavation incorporating clinker boat planking. E) Sketch of V section plank drain found in Hiberno-Norse Dublin, lined with clinker boat planking as seen on slide shown by Prof. McGrail in 1987.

Fig. 35 Map showing the location of British town and village sites yielding fragmentary nautical timbers of c.900-1600AD in approximate order of the magnitude of the finds. 1)Greater London and the City, 2)Perth, 3)Poole, 4)Lincoln, 5)Bristol, 6)Hull, 7)Grimsby, 8) Doncaster, 9)Newcastle, 10)Hartlepool, 11)York, 12)Medmerry, 13)Reading, 14)Southwold, 15)Yarmouth, 16)Southend, 17)Newport.

Fig. 36 Map showing selected European find spots of medieval and Viking period where reused nautical timbers have been found in quantity. 1)Bergen, 2)Dublin, 3)Wolin, 4)Schleswig, 5) Hedeby, 6) Gdansk, 7)Tonsberg, 8)Trondheim, 9)Amsterdam, 10)Tiel, 11)Novgorod.

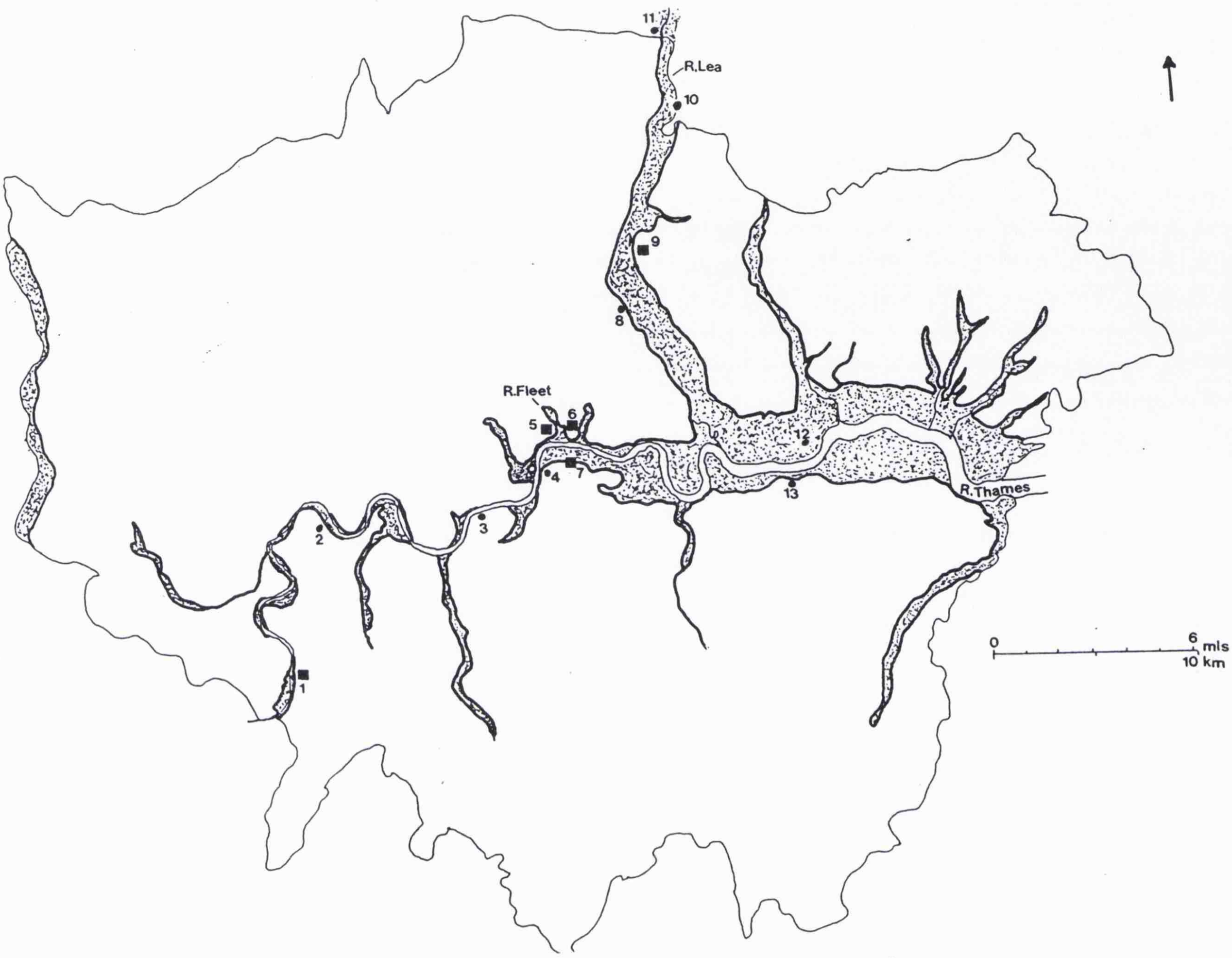


Fig. 37 Map showing the location of selected excavated groups of boat and ship timber finds and vessels in the London area overlaid on the areas of alluvium as mapped by the Geological Survey for London. Dots are single find spots, Squares multiple finds, numbered symbols represent the find location of the following- 1) Medieval Kingston Horsefair finds, 2) Kew dugout, 3) Post-medieval Battersea barges? 4) Roman County Hall ship, 5) Post-medieval Boys School timbers, and medieval Tudor st. find, 6) Numerous City of London finds of Roman to medieval date including the Blackfriars wrecks, 7) Southwhark finds including the scheduled Roman New Guys House boat, and numerous other finds of pre-Conquest to post-medieval date, 8) Clapton Late-Saxon dugout, 9) 2 Walthamstow post-medieval clinker built barges, and dugout, 10) Sewardstone dugout, 11) Waltham Cross dugout, 12) Albert Dock dugout, 13) C16th Woolwich ship. (references to these finds can be found in Append.6 and Marsden 1996).

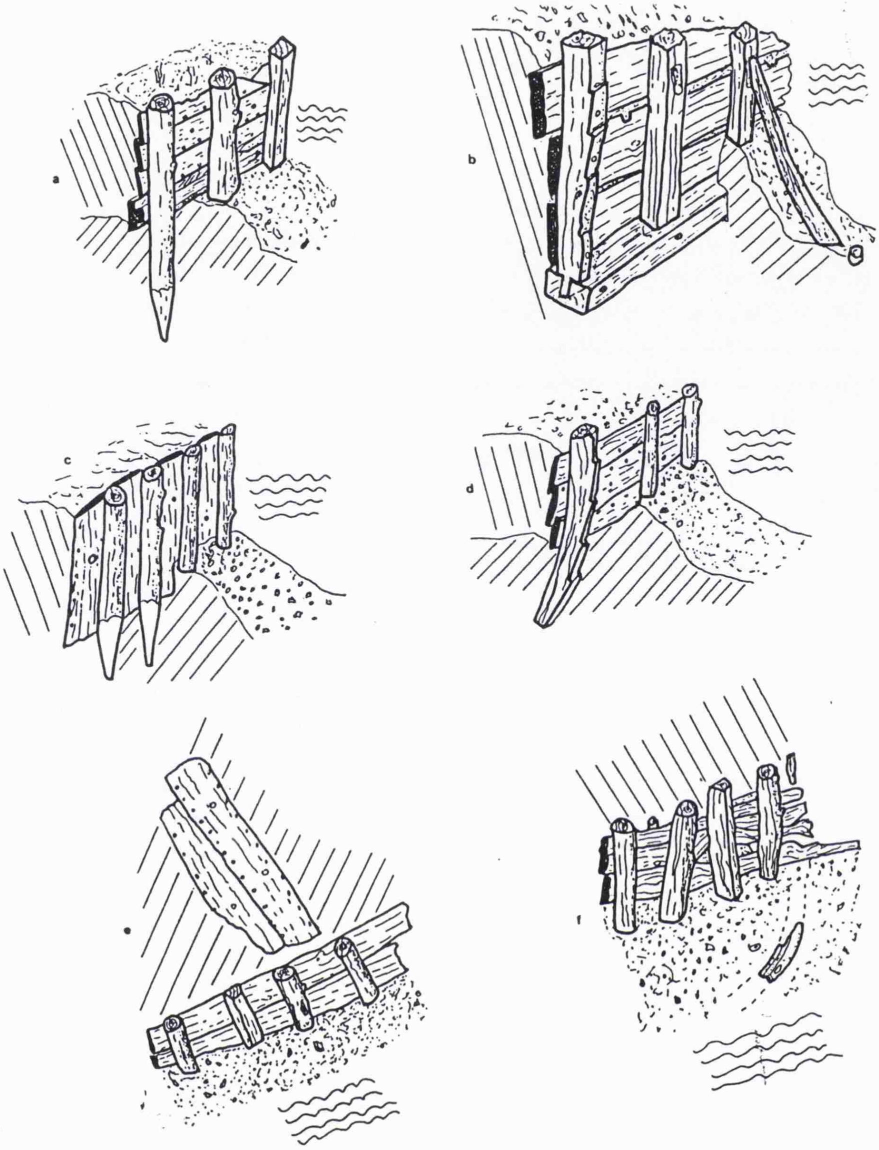
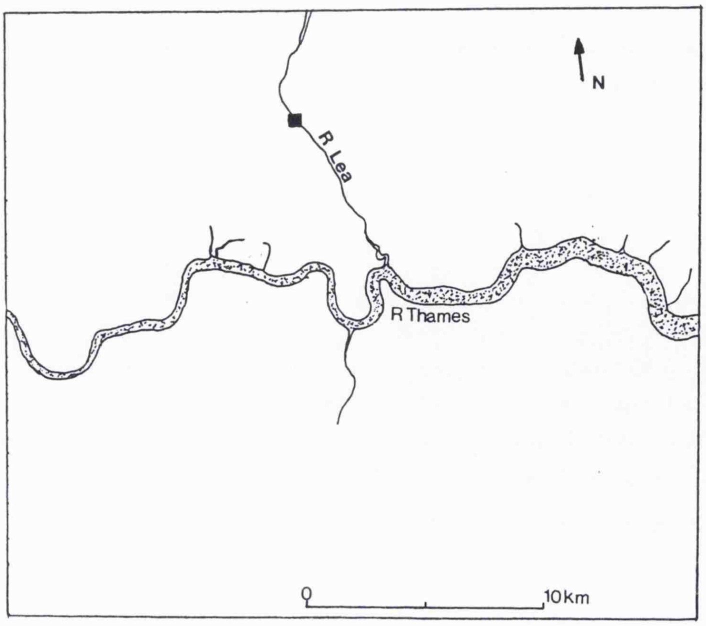


Fig. 38 Sketches showing common types of structural reuse and other find contexts of medieval nautical timbers on waterfront sites.
A) As plank sheathing of simple pile and plank revetments, as found at Thames Exchange, Vintners Place, and Bull Wharf etc. London, and Kingston Horsefair. B) Frame elements as posts in framed revetments such as the later medieval revetment at Baynards Castle. C) Planking as vertical driven shuttering as found at Vintners Place. D) Frame elements as piles for pile and plank revetments, as found at Bull Wharf. E) As plank "duckboards" over soft ground, as found at Bull Wharf. F) As drift wood on relict foreshores, sketch shows a small fragment of Pre-Conquest boat stem found at Vintners Place.



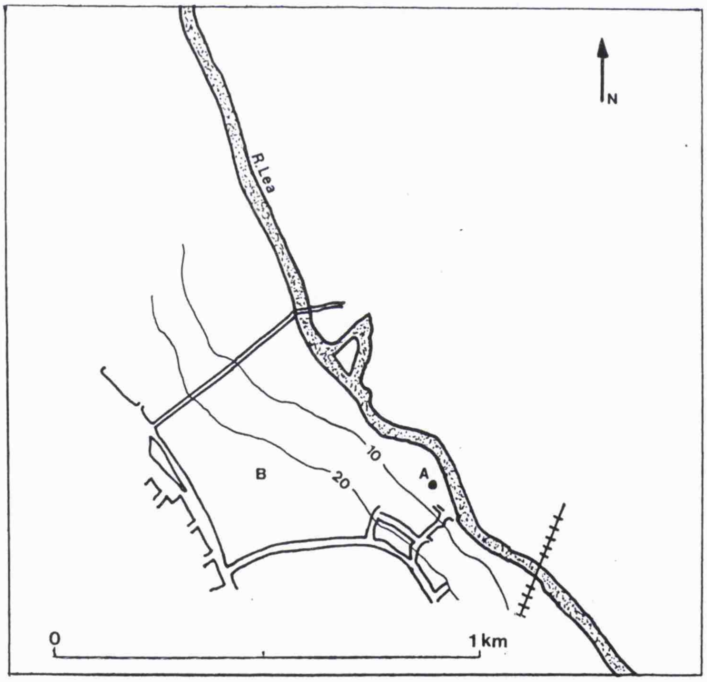


Fig. 39 Maps showing find spot of the Clapton Dugout boat, Top the R. Thames in central and E London and its confluence with the R. Lea (Lee). Bottom the R. Lea A), Where the boat was found, B) Springfield park.

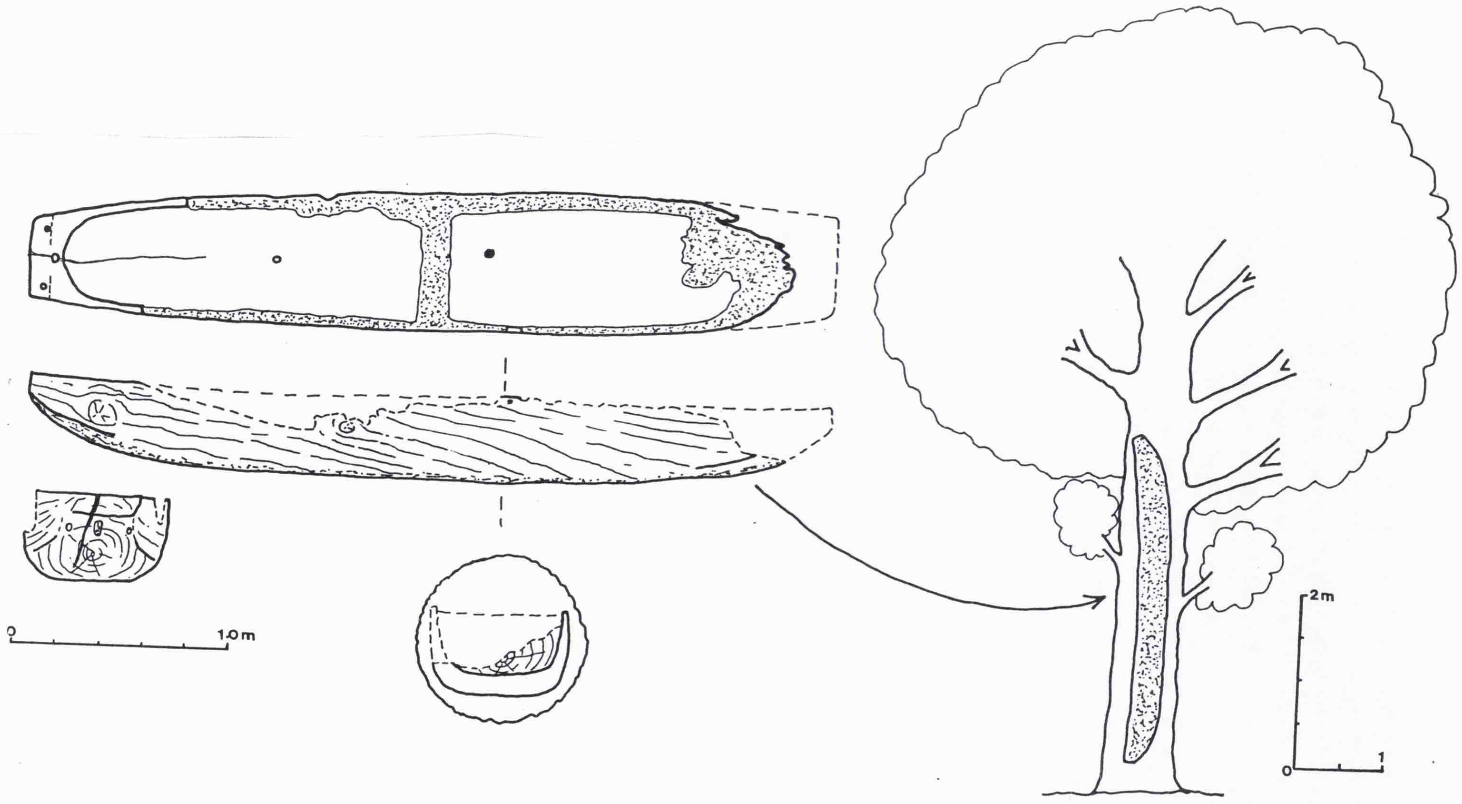


Fig. 40 The 10th century Clapton dugout boat and its reconstructed parent oak.

Fig. 41 The replica of the Clapton boat undergoing loading trials with, peat, firewood and salt as cargo on the punt racing course, at Taplow on the R. Thames. (Photo. V.Fenwick).

Fig. 42 Punting the replica of the Clapton dugout boat at LLyn Langorse, Wales. (Photo author).

Fig. 43 Paddling the Ravensbourne Clapton Dugout boat replica through power boat wash (equivalent to small estuary waves), with 2 adults, Taplow on Thames. (Photo V. Fenwick).

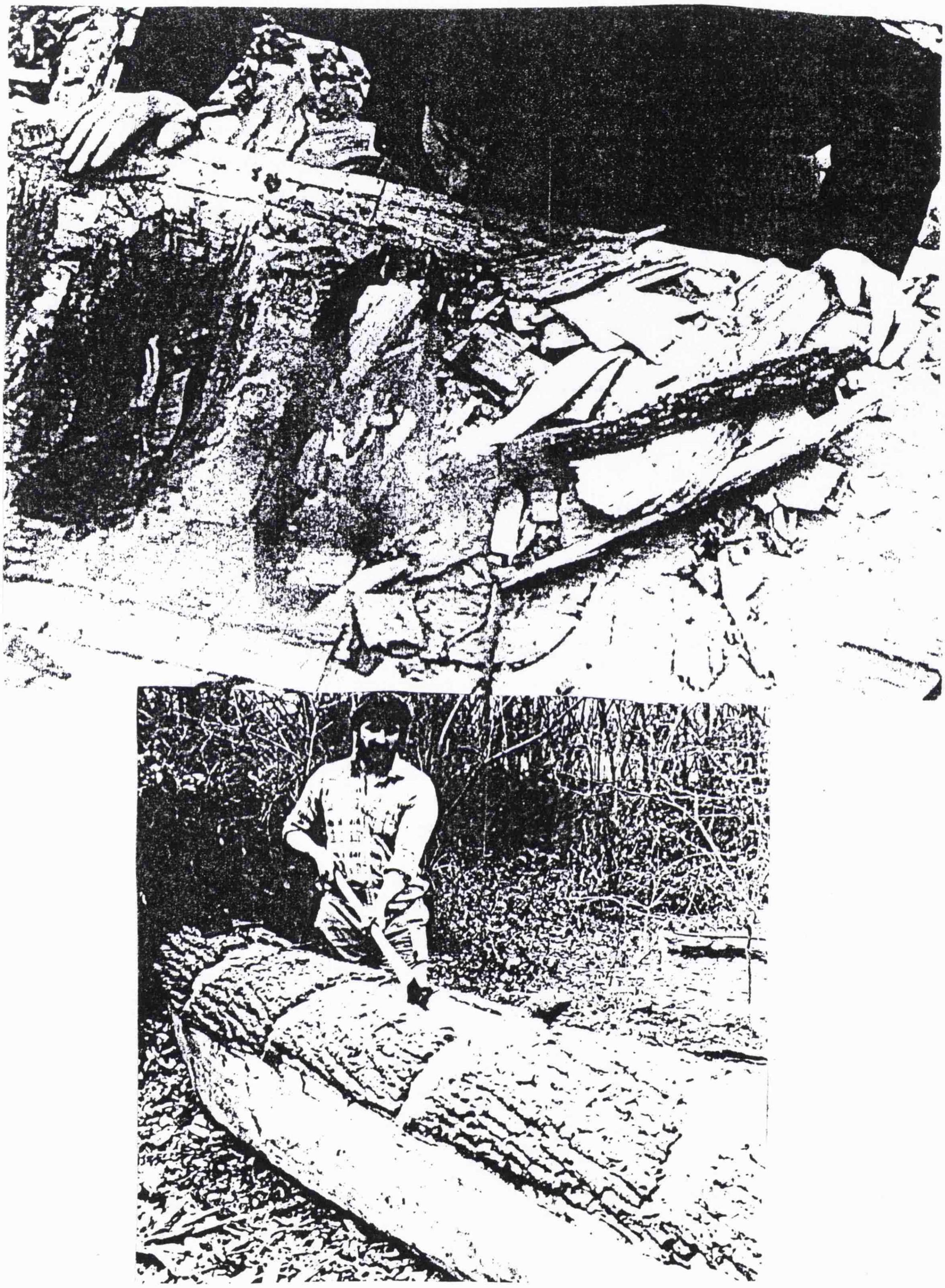


Fig.44 Removing waste timber during the building of 2 medieval dugout boat reconstructions. Top, an abortive attempt at fire hollowing of the Loch Doon 1 replica, Anstruther Fisheries Museum, Fife. (Photo Author). Bottom, using the axe cut 'groove and splinter' technique to split off waste, from the top of the Clapton boat replica, SE London. (Photo M. Redknap).

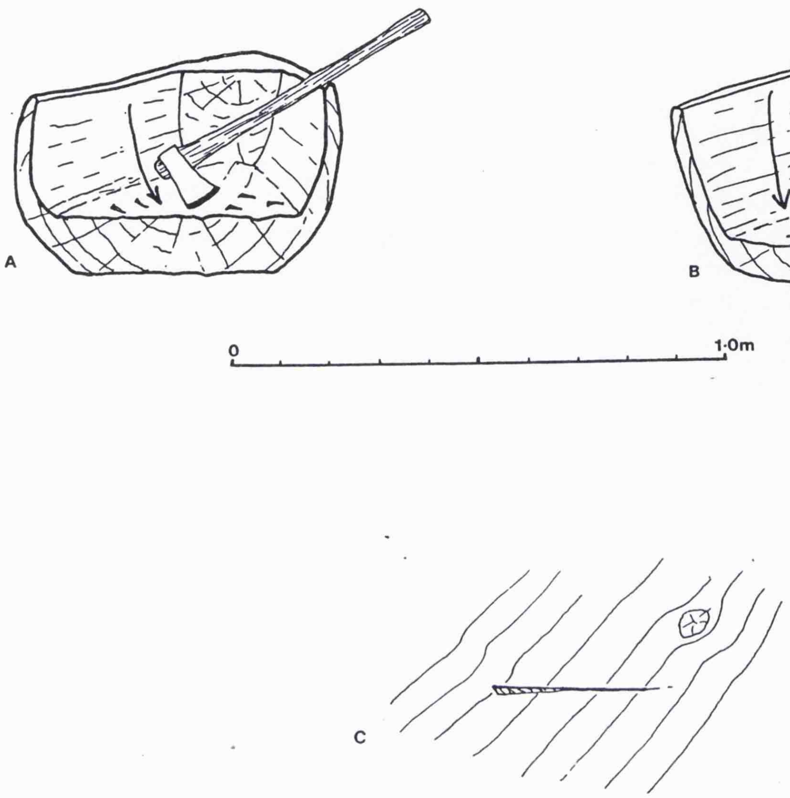


Fig. 45 Diagrams showing how axes were used, to nick the the waste in the bottom of two dugout boats, prior to its removal. A) The 7th century Loch Doon 1 boat, SE Scotland, B) The 13th century Wasdale Beck boat, Cumbria. C) A typical axe incut mark, where the corner of the tool bits in

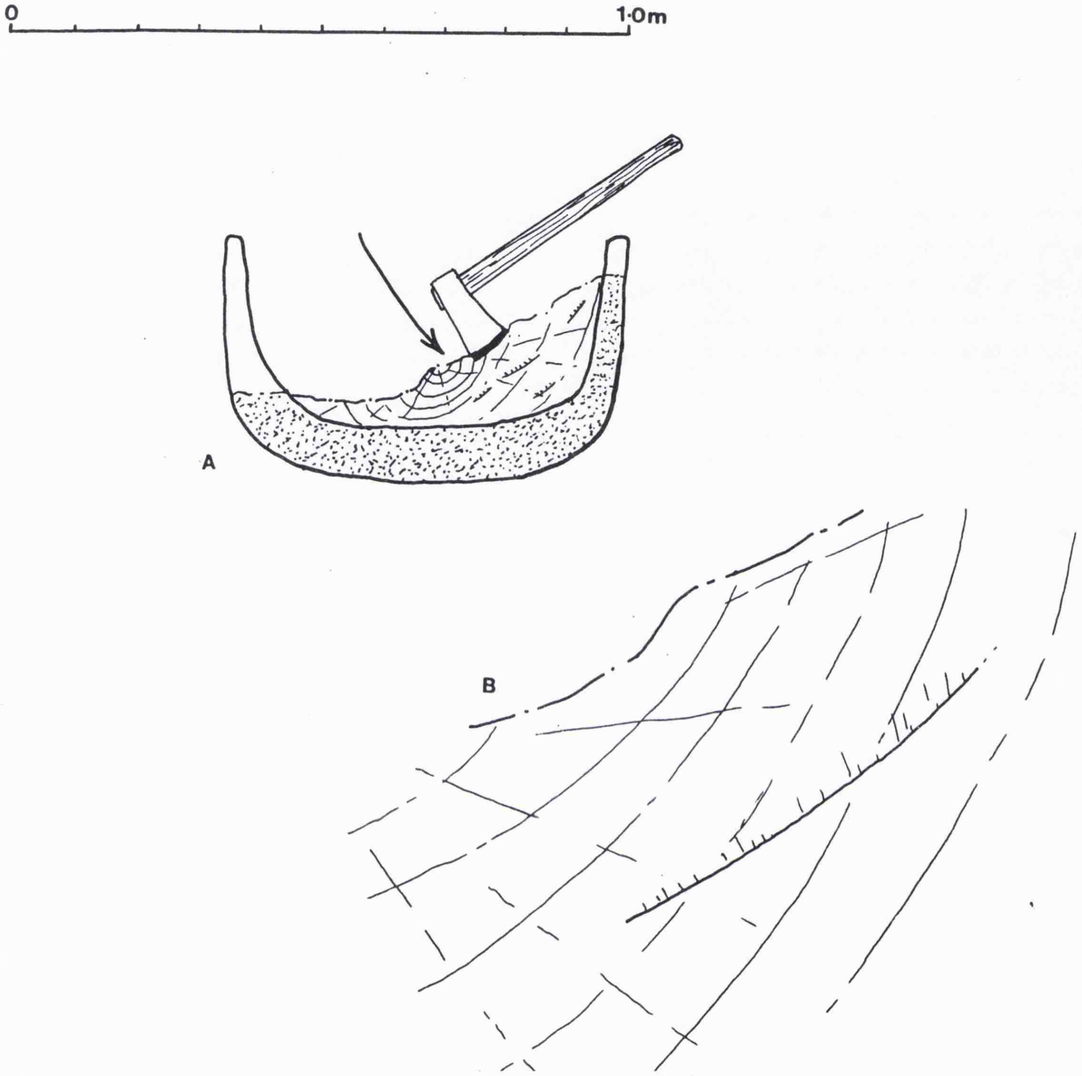


Fig. 46 Axe marks on the solid hewn bulkhead of the 10th century Clapton dugout vessel. A) Shows mode of use of axe. B) Close up of the axe stop-mark.

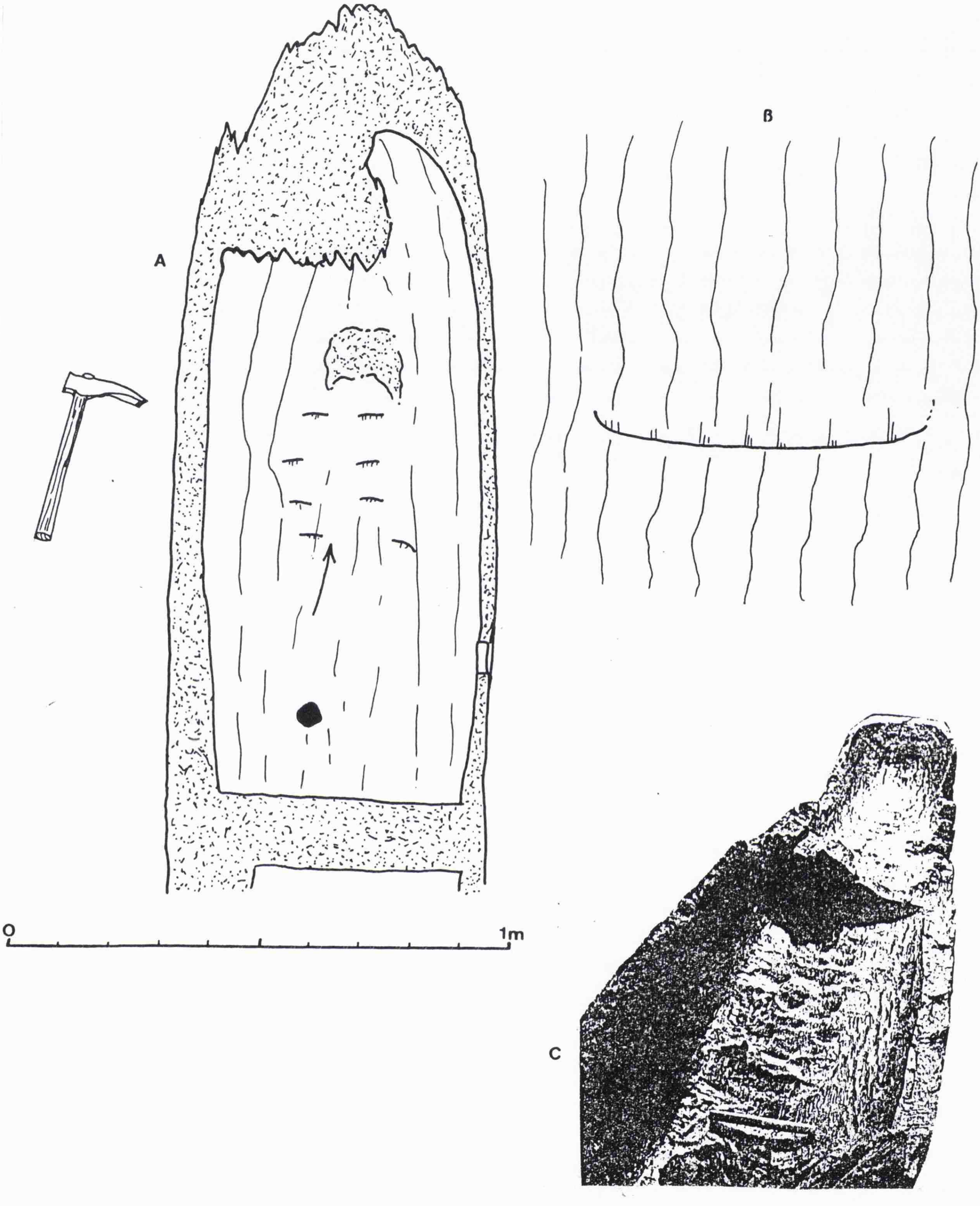


Fig. 47 Sketches showing the adze marks in the central part of the bottom of the Clapton boat. A) A schematic plan of the adze marks. B) Detail of adze stop mark. C) Photograph of the original boat in raking light showing the general character of the marks. (Photo P. Marsden).

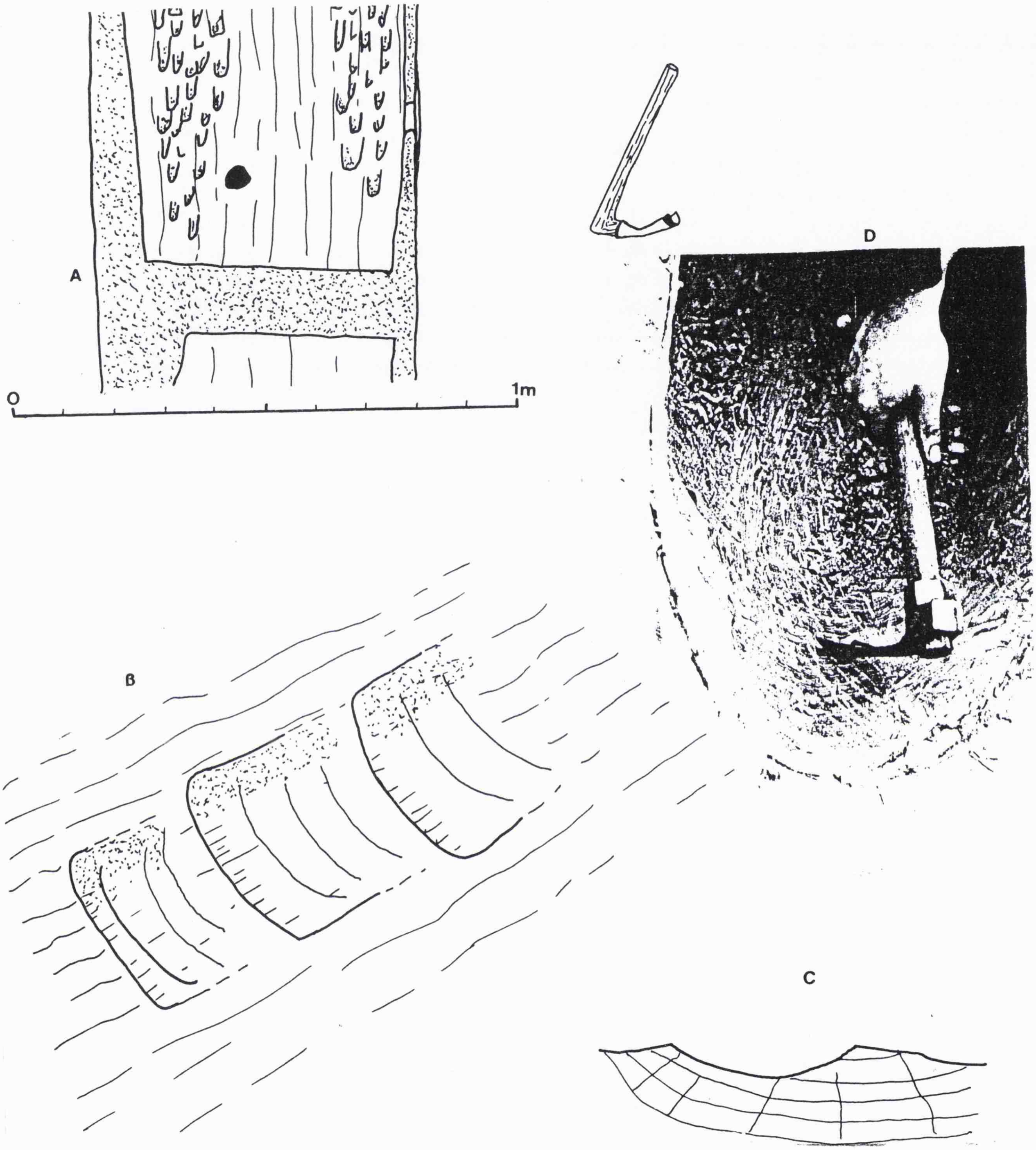


Fig. 48 Sketches showing the gouge adze marks found on the inside of the Clapton dugout boat; black spot is a waxed and bunged thickness gauge hole. A) The location of the concave marks in the turn of the bilge. B) Detail of the gouge adze stop marks. C) Cross section of a typical gouge adze facet. D) Photograph showing the use of a gouge adze on the Clapton dugout replica, in 1988. (Photo. author).

Fig. 49 Boring a thickness gauge hole through the inverted bottom of the Clapton dugout reconstruction. (Photo author).

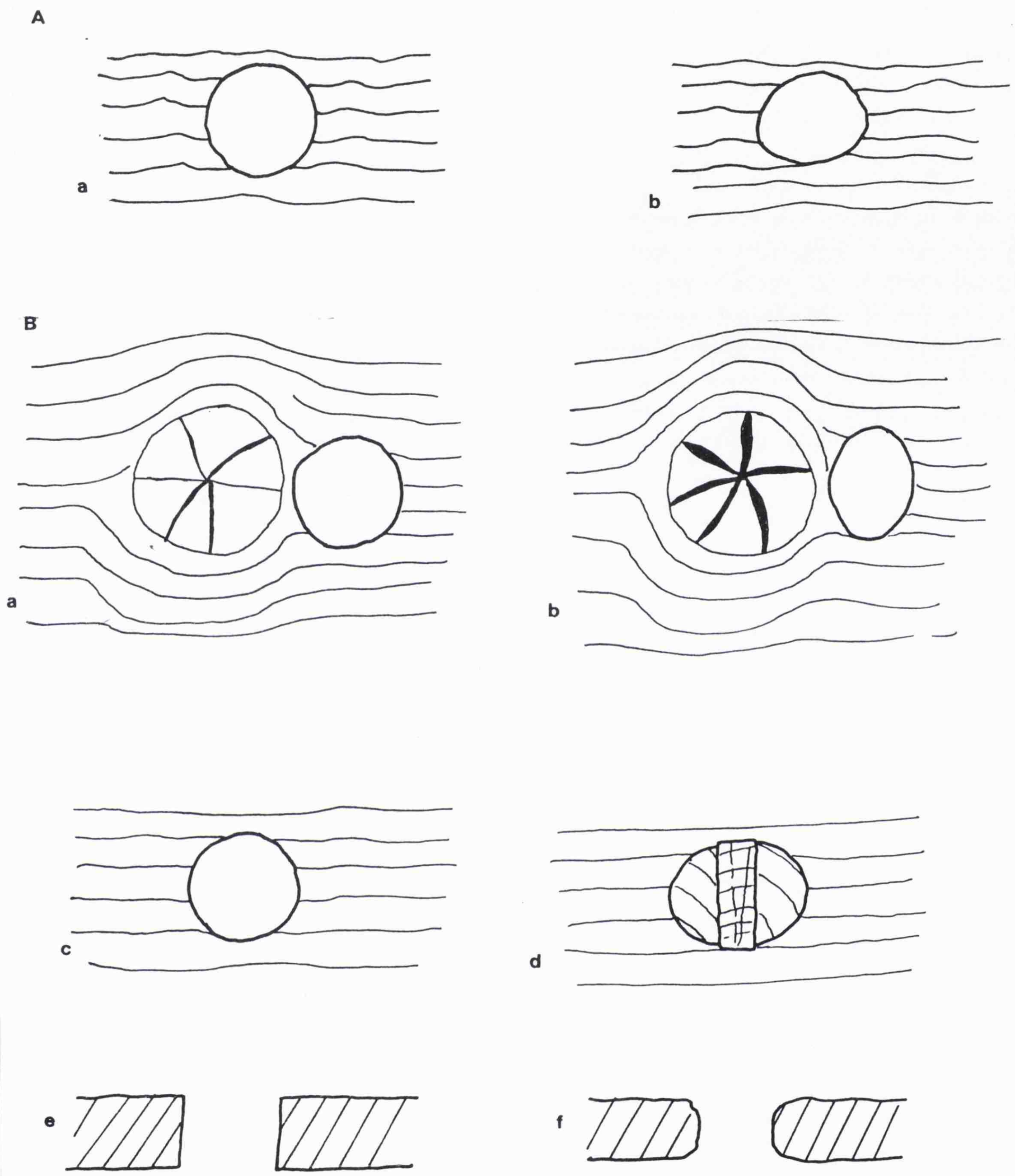


Fig. 50 Diagrams showing how holes in waterlogged timber can distort.
A) Top, a, hole in fresh oak, b, typical hole shape in shrunken medieval waterlogged oak.
B) Bottom, a, hole in fresh oak near knot, b, distortion on drying, c, hole in fresh oak, d, hole distorted by wedged treenail, e, cross section of hole in fresh oak, f, typical eroded ancient hole.

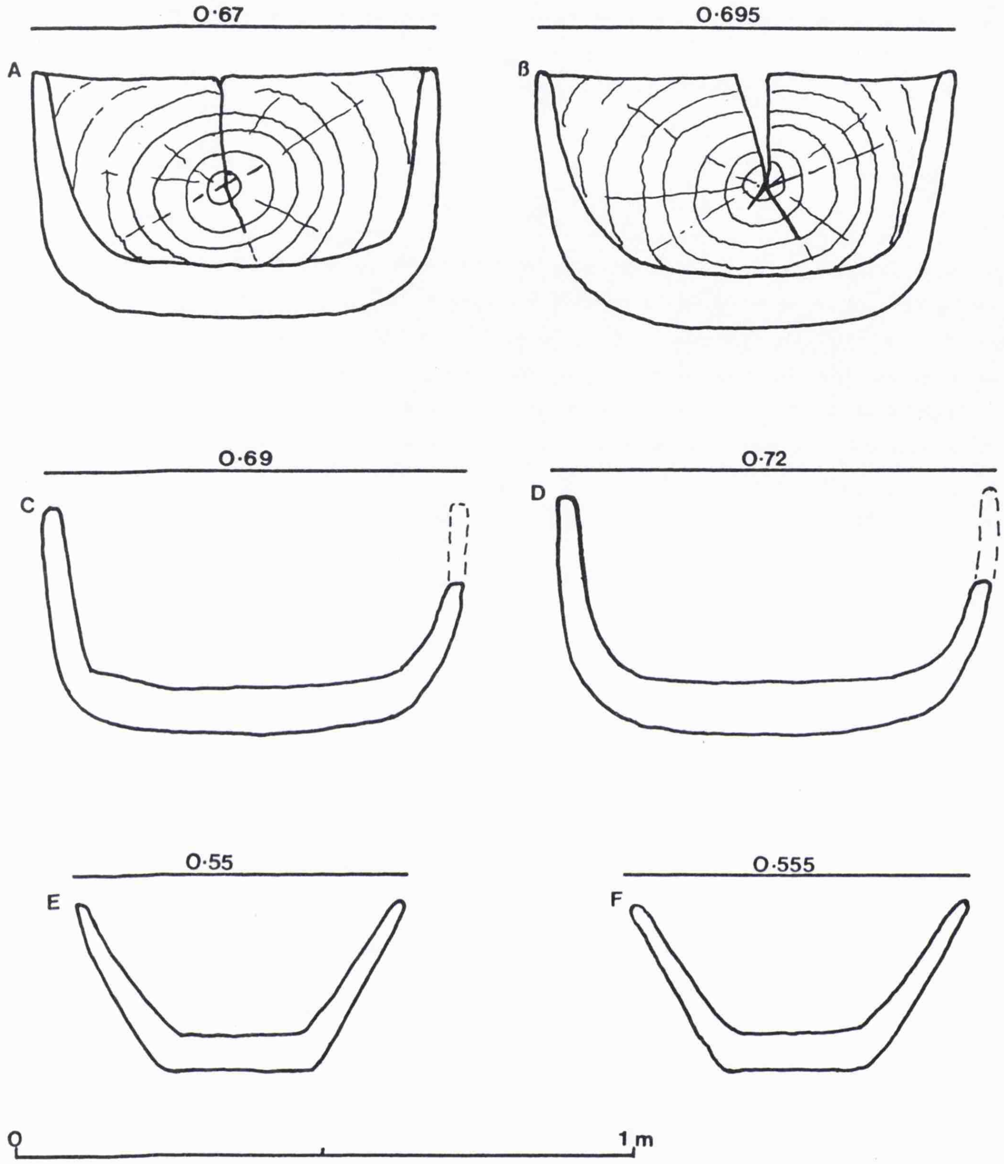


Fig. 51 Cross sections, near midships of 3 oak dugout boats showing distortions on drying and changes in beam in m.. A) The Clapton boat replica after completion in May 1988. B) The same cross section in August 1992. C) The Wasdale Beck boat as conserved and recorded May 1990. D) Approximate as-found cross section derived from preconservation measurements. E) The dugout base of the Kentmere boat replica as completed June 1990. F) As measured after seasoning out of the water in damp shade, August 1992.

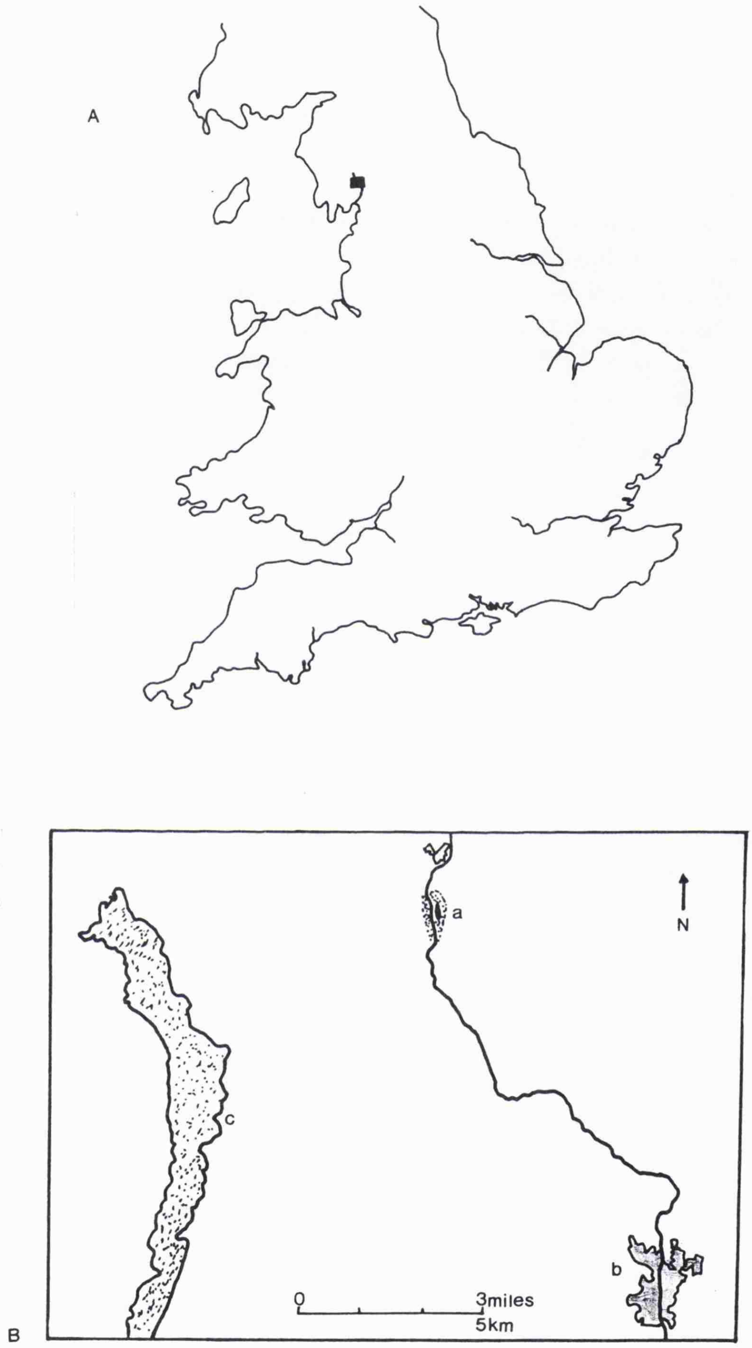


Fig. 52 Maps showing the find spot of the Kentmere extended dugout. A) The position of the local map is indicated by the black square. B) The Kentmere 1 find spot in a silted mere a), (redrawn from Wilson 1966), b), the town of Kendal, c) Lake Windemere.

A

B

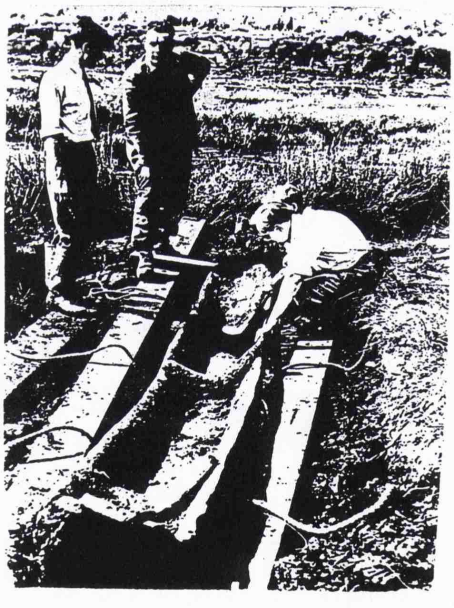


Fig. 53 The excavation of the Kentmere extended dugout boat. A) The finder of the boat holding one of the smaller hull boards next to the flattened remains of the hull in 1955. (Photo NMM.). B) The dugout base of the Kentmere 1 boat with lifting ropes passed underneath 1955. D.M.Wilson on the left (Photo NMM).

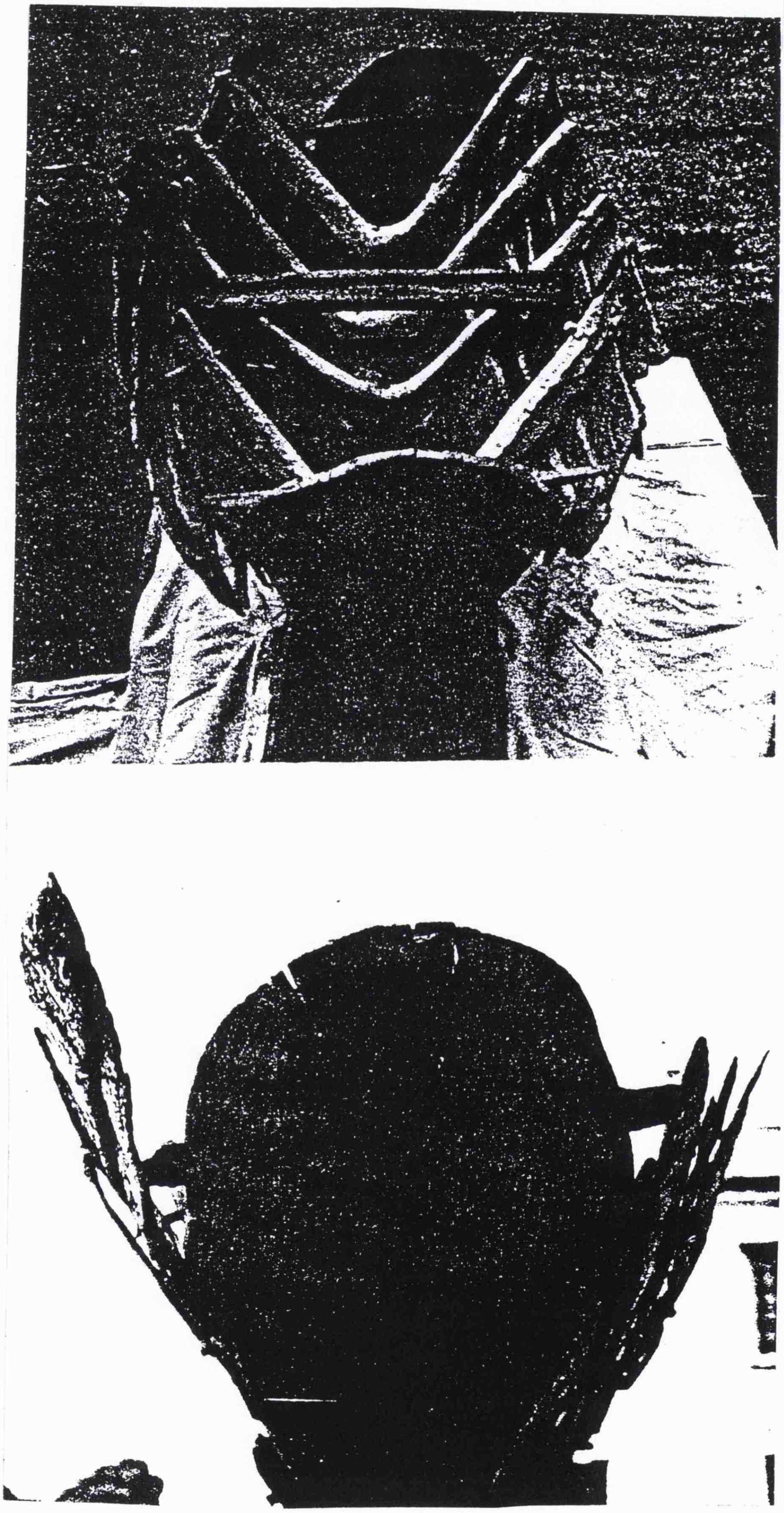


Fig. 54 The attempted reassembly of the dried hull of Kentmere 1 in 1966 at the NMM Greenwich. A) Looking for'ad. B) Looking aft. (Photos. NMM).

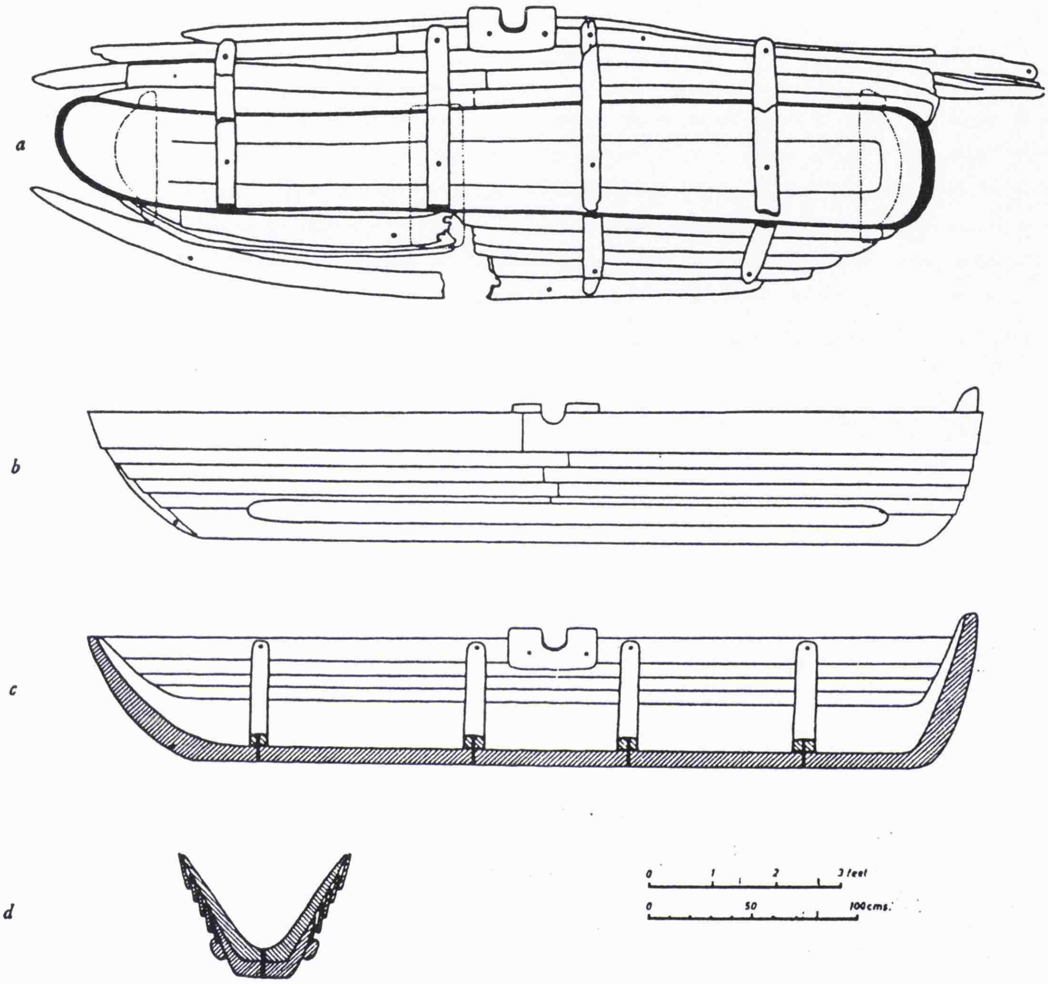


Fig. 55 The Kentmere 1 boat as presented by D.M. Wilson in 1966 (after Wilson 1966); a) partially reconstructed plan of timbers in situ, b) reconstruction of port side, c) reconstruction of inside of starboard side, d) reconstructed cross section.

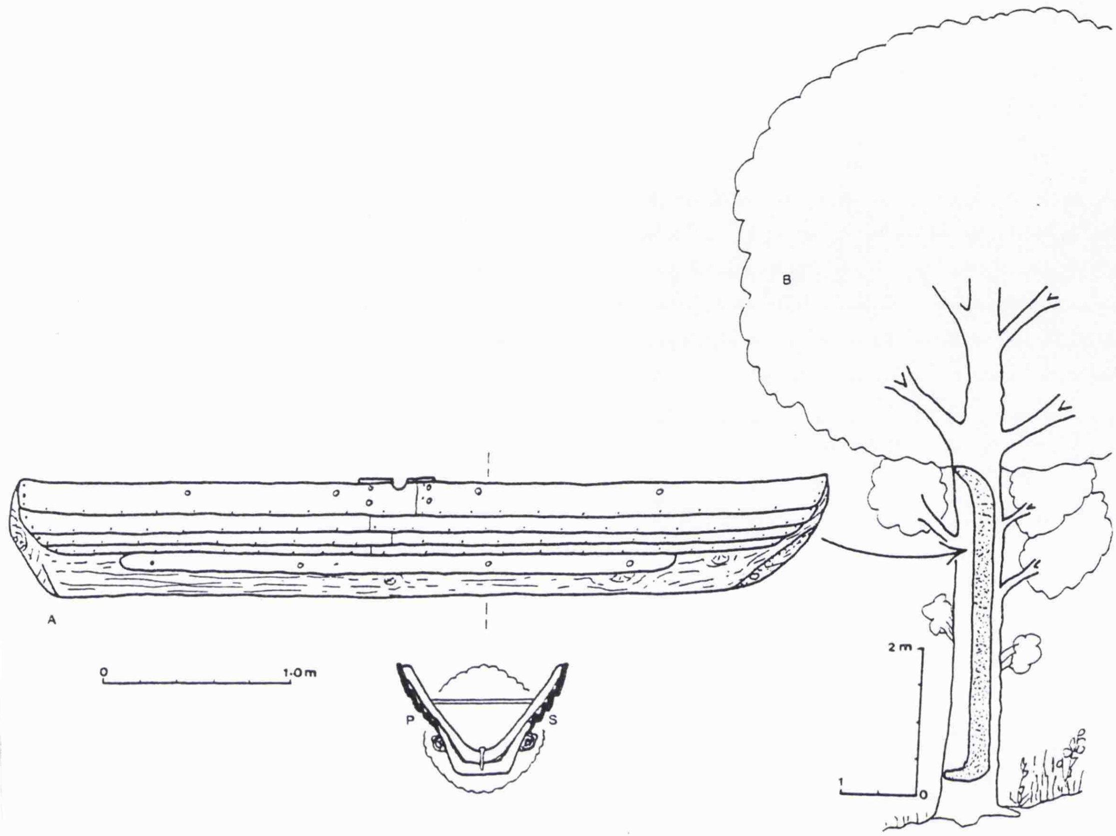


Fig. 56 A new graphic reconstruction of the c. 1300 Kentmere 1 boat. A) A view of the Stbd. side and cross section, S= starboard, P= port. B) The hypothetical parent oak used for the dugout base.

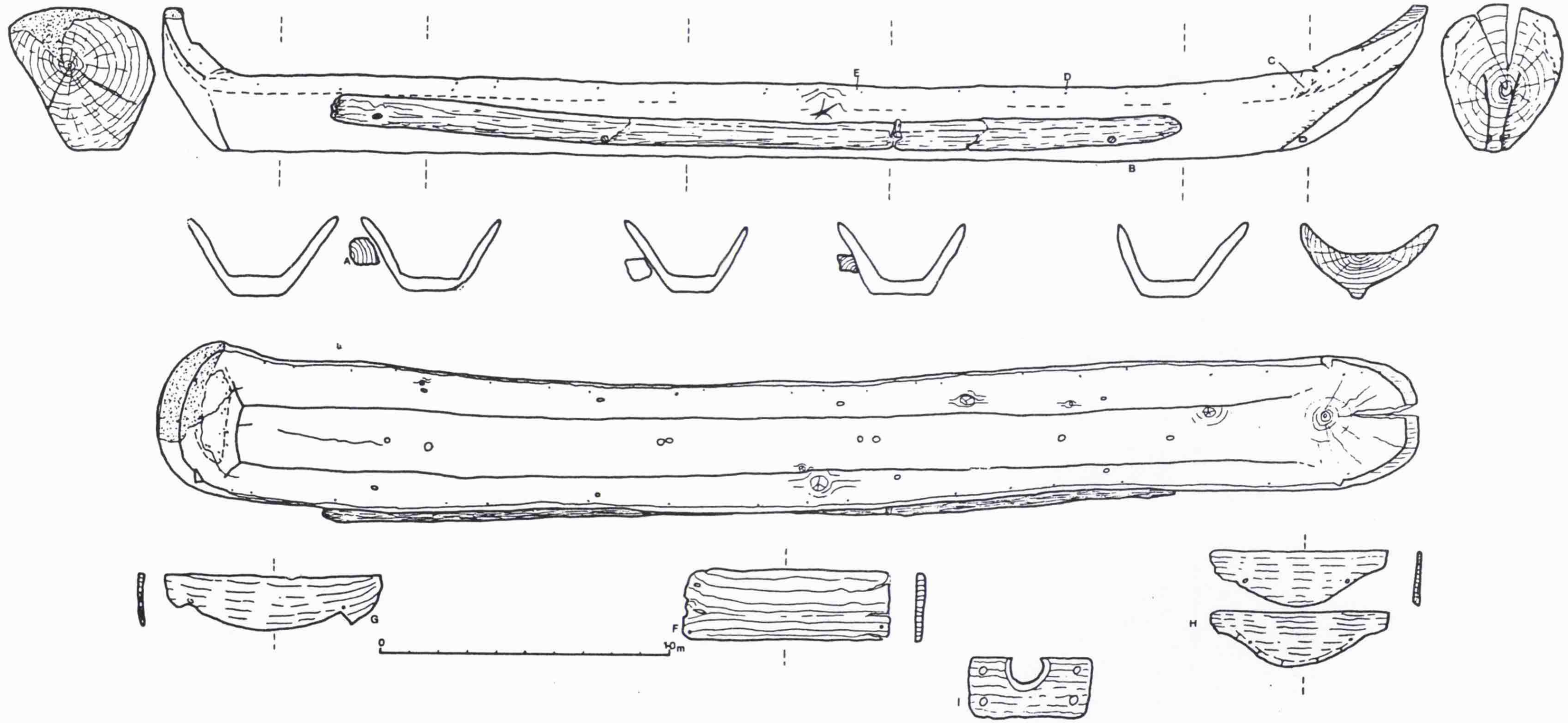


Fig. 57 The dugout base of the Kentmere 1 boat as recorded by the author in July 1988, stern shown to the left; a) A birch stabiliser log still attached, b) the point where the slight rocker of the bow begins, c) the faying area of the lap with the first strake, with faint axe marks shown, d) ancient lap nail hole (?), e) a hole apparently dating to the 1966 attempt at reconstruction, f) the ash central thwart, g) the oak stern thwart, h) the oak bow thwart, i) the surviving ash 'orloke'plank from a sketch of timber on display at NMM.

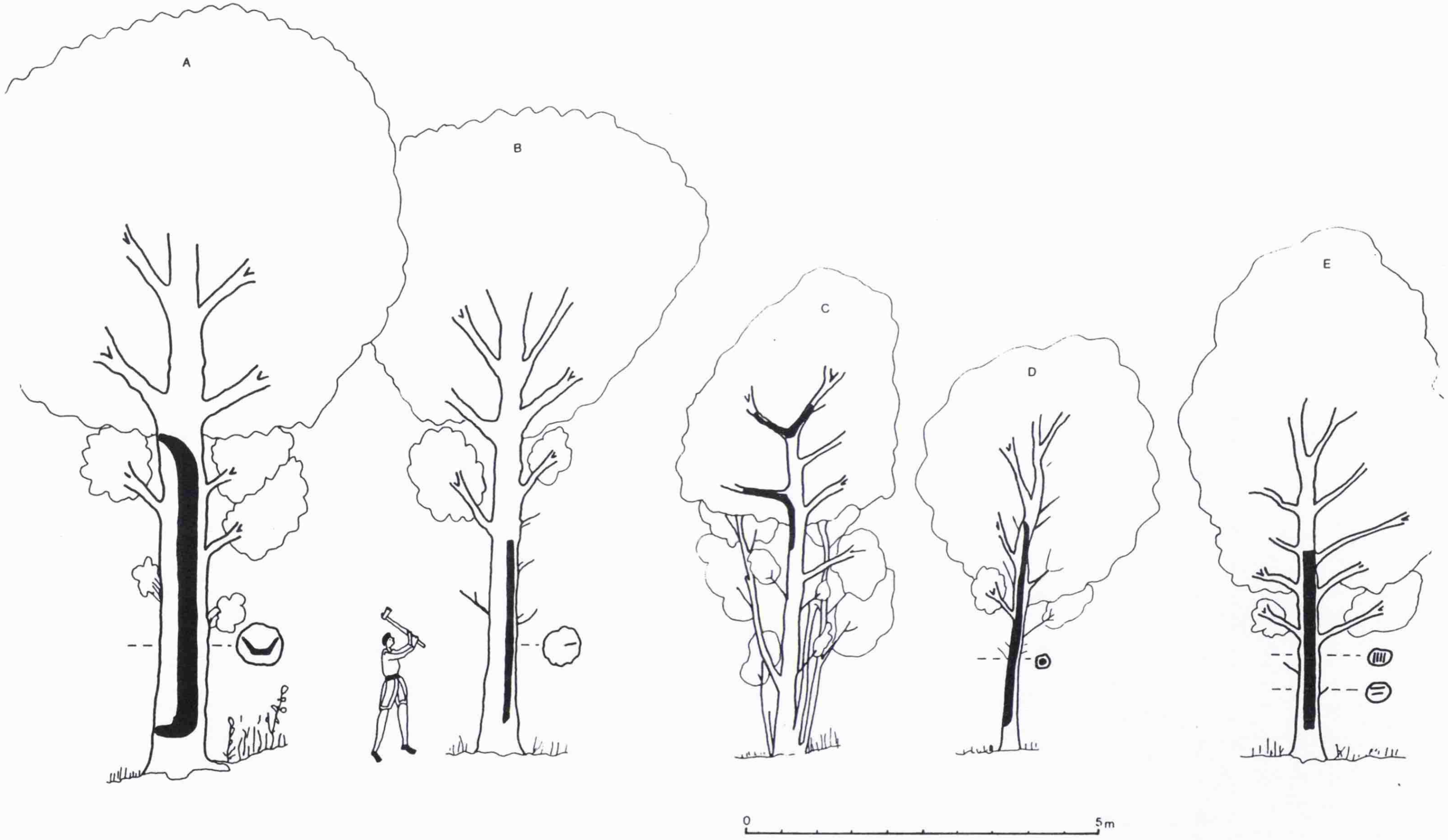


Fig. 58 The reconstructed hypothetical parent trees used for elements of the Kentmere 1 boat, a) The oak for the dugout base, b) the oak for the radially cleft hull planks, c) the birch and hazel trees used for the grown ribs, d) the birch used for the stabiliser logs, e) the oak for the tangentially faced sheer strake planks.

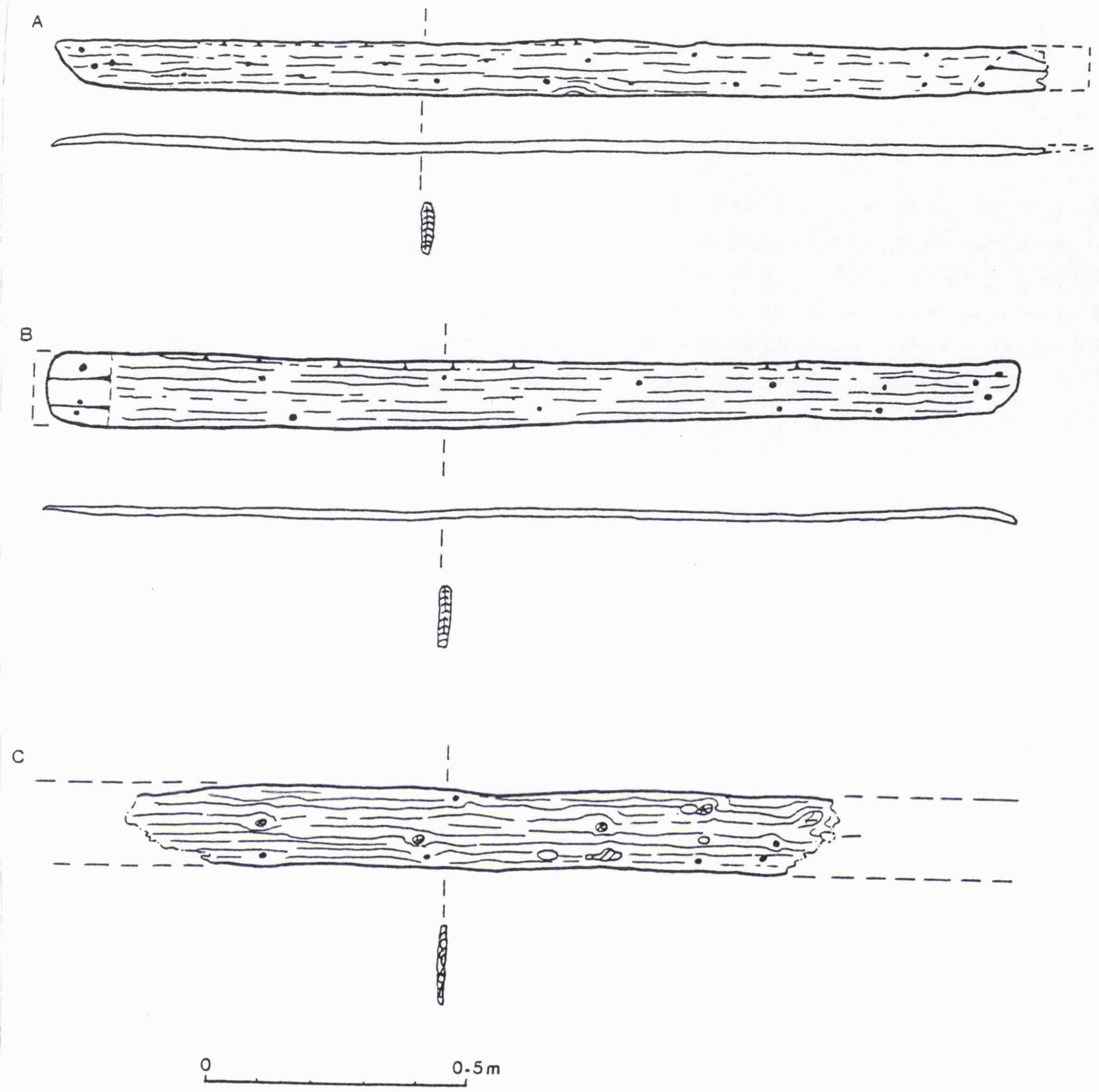


Fig. 59 Samples of the hull boards of the Kentmere 1 boat, extended dugout, a), radially cleft oak board with label "S1.1..5". possibly for'ad section of 1st strake starboard side (?), b) radially cleft oak board unlabelled, possibly port side for'ad (?), c) tangentially faced oak plank fragment, labelled "P5.2.36.", probably part of the sheer strake port side.

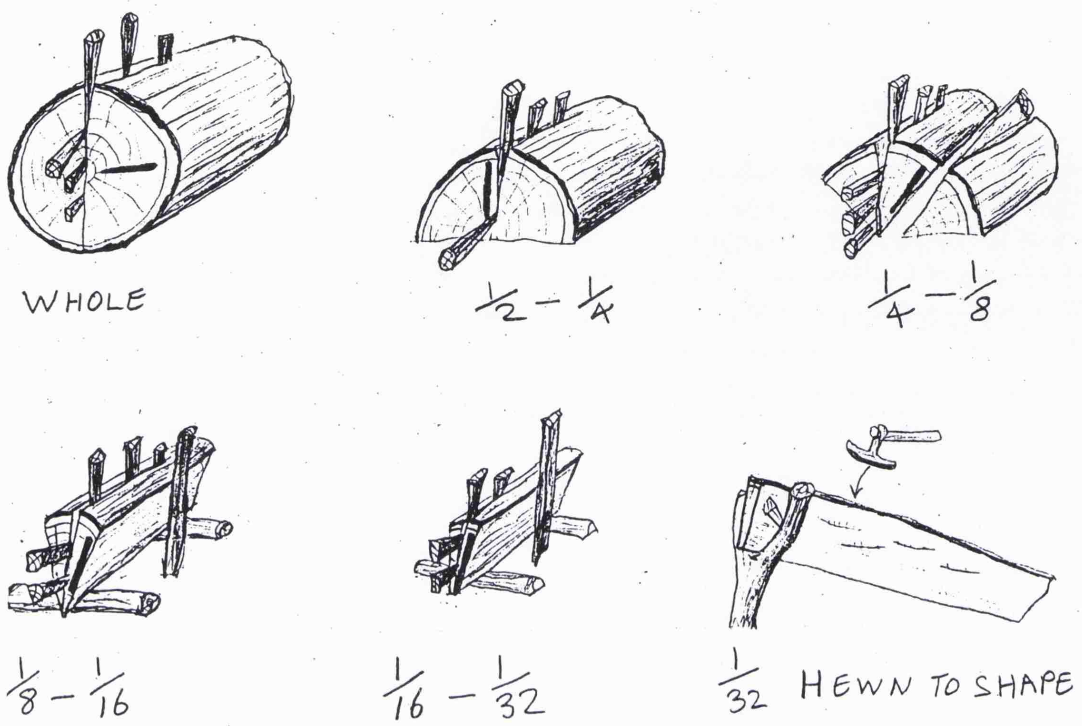


Fig. 60 Diagram showing the basic steps in cleaving an oak log radially for typical medieval ship boards.

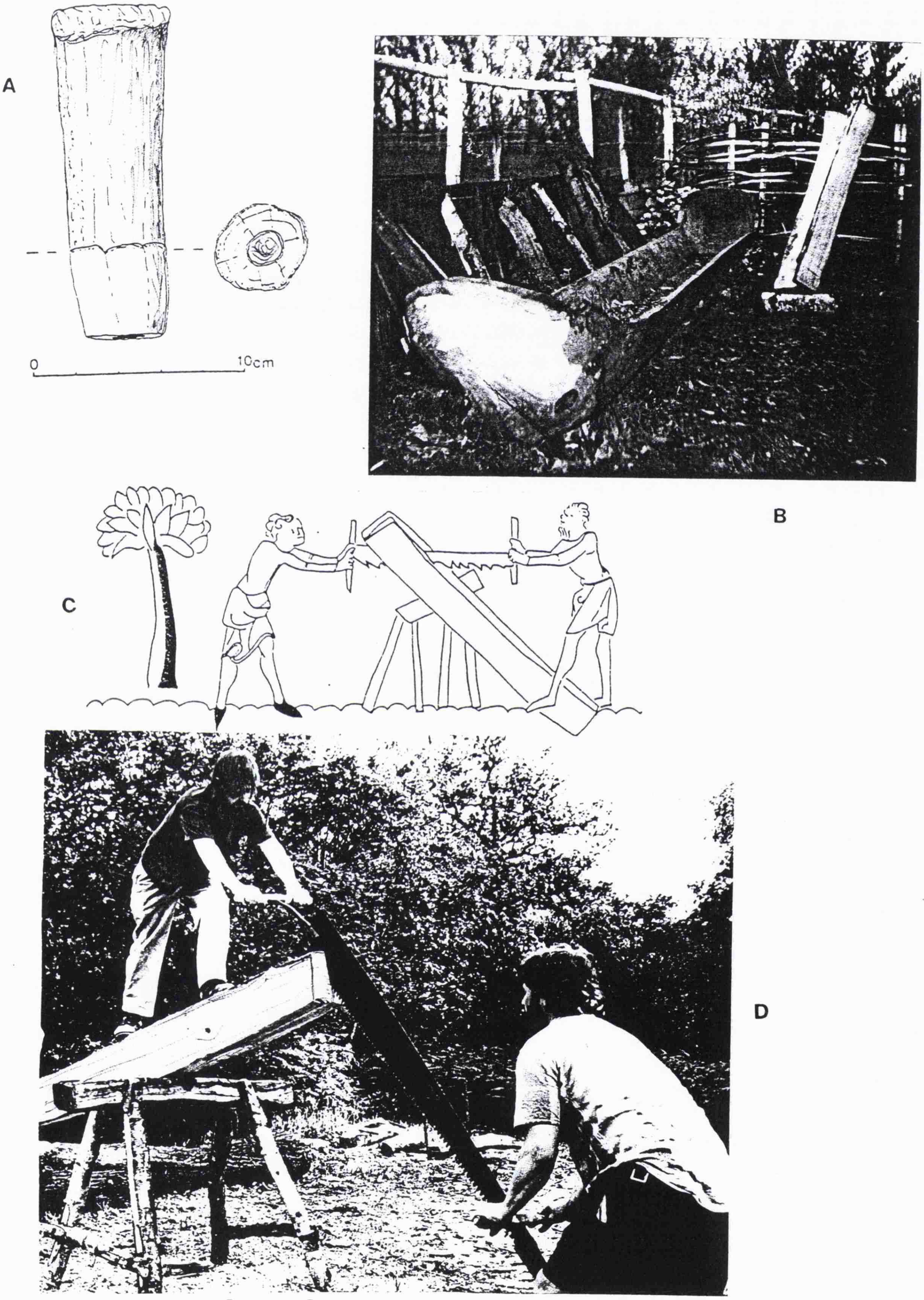


Fig. 61 Tools and techniques used in building the experimental replica of the Kentmere 1 boat of c. 1300AD. A) A holly rove set. B) The finished replica dugout lower hull and first cleft boards ready for trimming to fit. (Photo author). C) 14th century image of see-sawing timber (From Decretals of St. Gregory, St. Bartholomew's priory London, c. 1340). D) Experimental see-sawing of a hewn oak baulk in the 13-14th century style. (Photo. C. Milne).

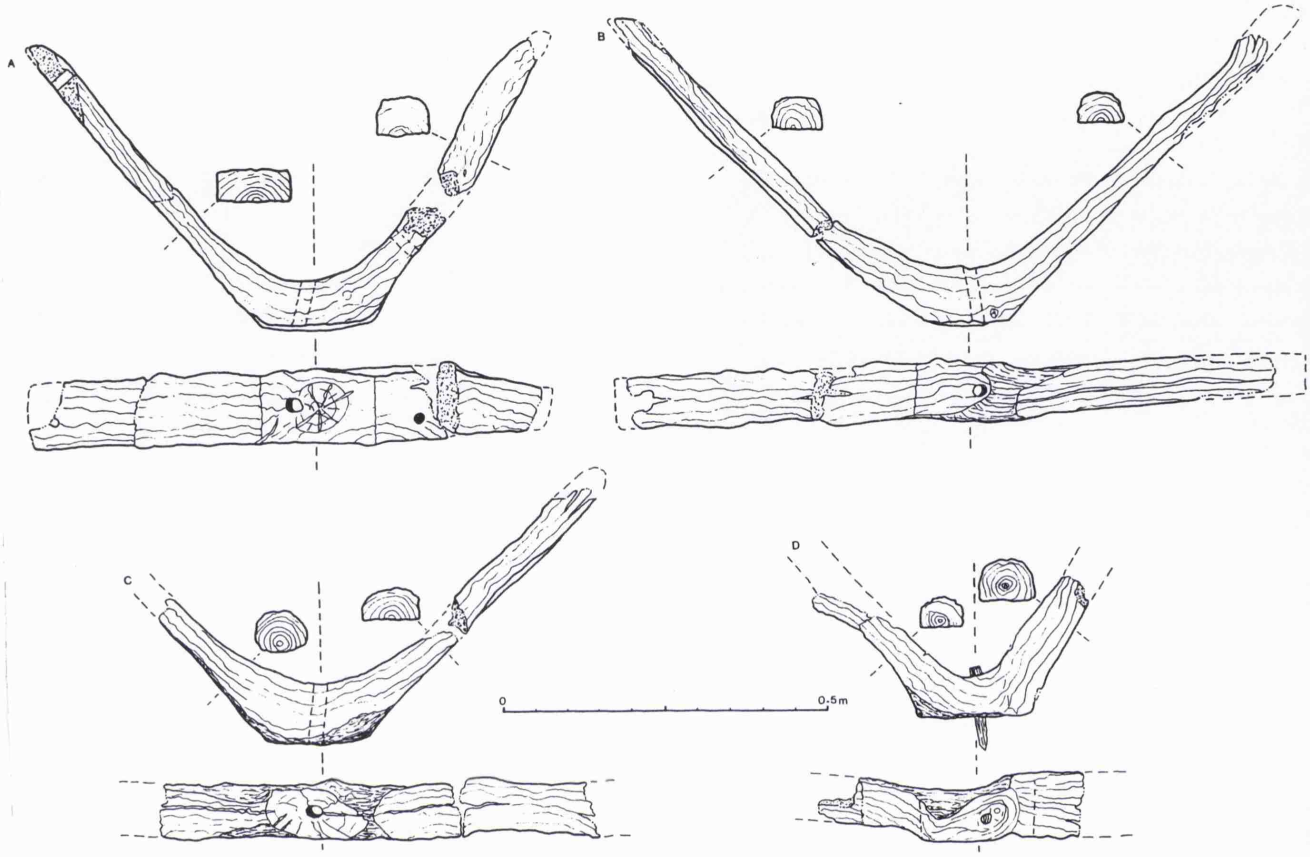


Fig. 62 The grown ribs of the Kentmere extended dugout.
A) Probably the aftermost rib. B) The next for ad.. C)
The next for'ad.. D) Probably the bow rib.

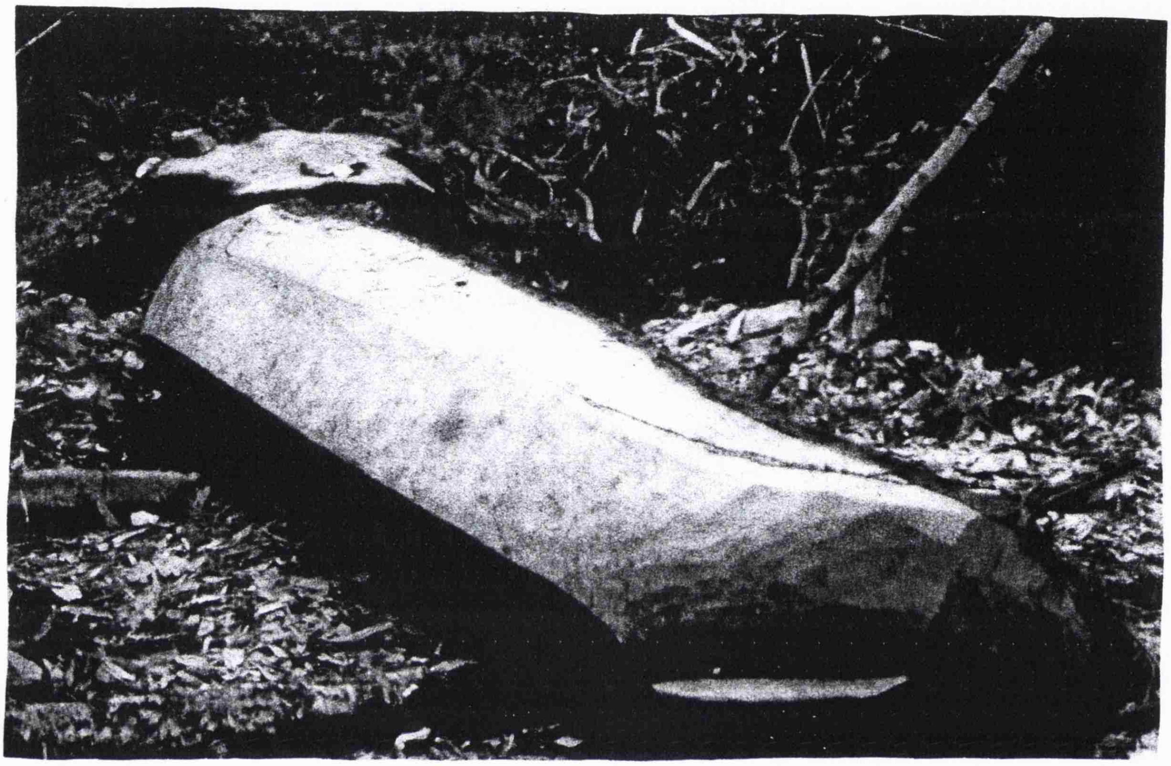


Fig. 63 The lower hull of the experimental replica of the Kenmere extended dugout of c. 1300 AD during hewing out in ancient woodland SE London. The bottom has been hewn, it is about to be rolled onto its flat base. A charcoal line marks the intended upper edge of the dugout base. (Photo. author).

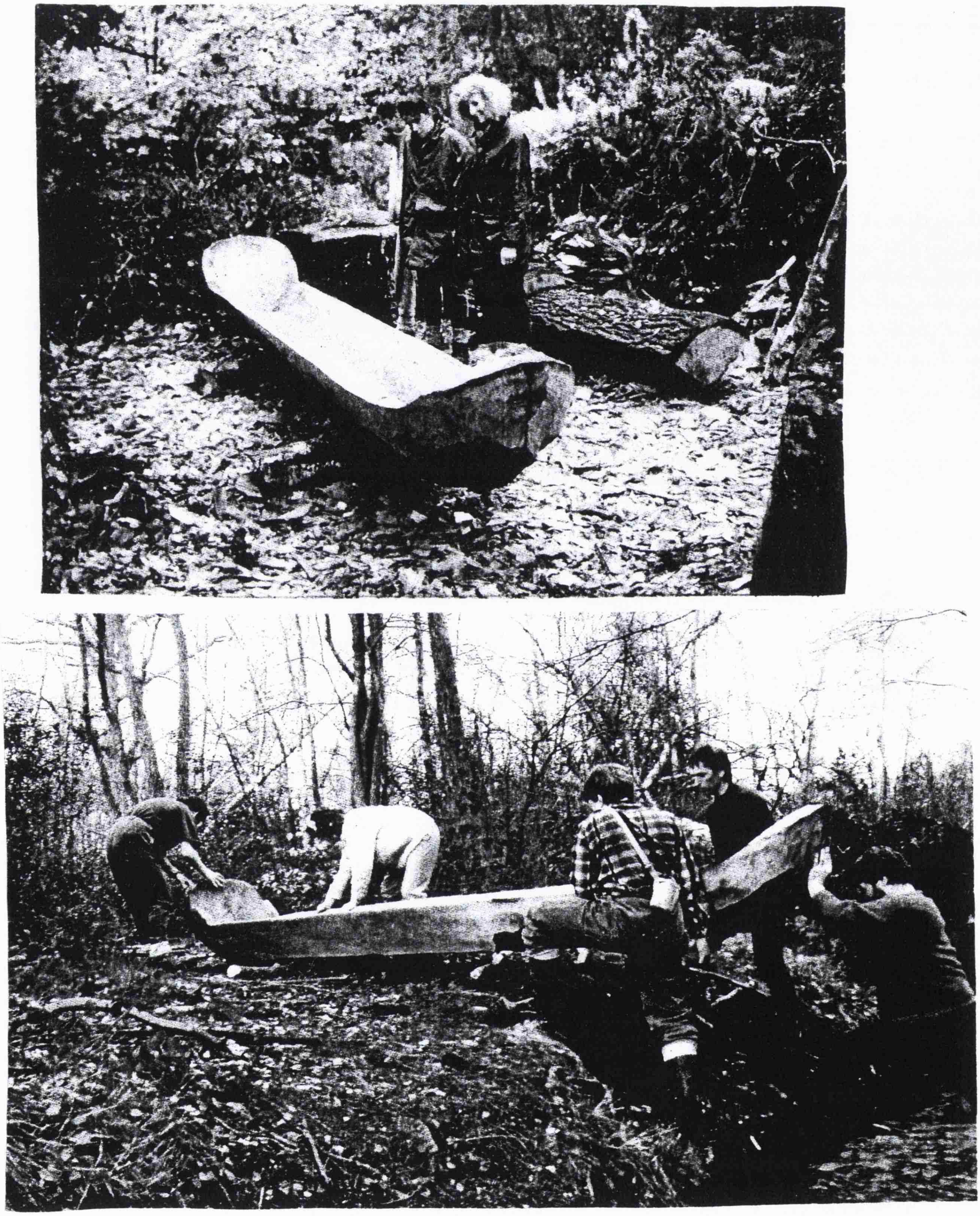


Fig. 64 Extracting the experimental Kentmere 1 boat replica dugout base. A) About 90% finished Barnet wood, London. (Photo author). B) 4-5 adults moving the green bottom section along a woodland path and over a small stream using branches as skids. (Photo. C. Milne.).

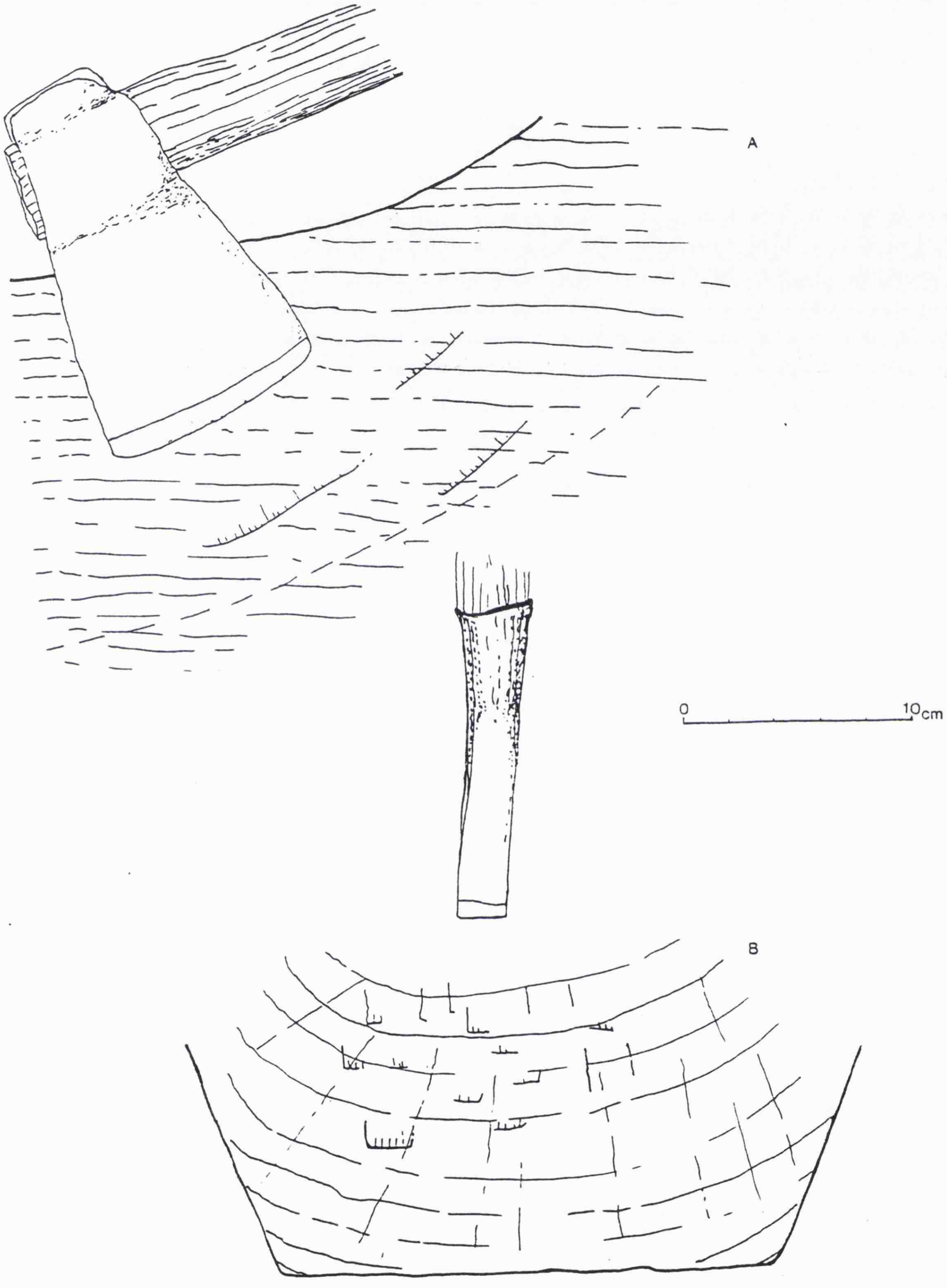
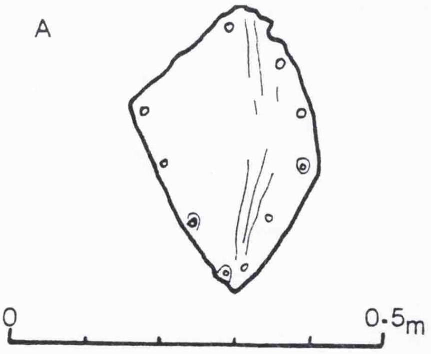


Fig. 65 Toolmarks on the Kentmere extended dugout base. A) The disposition of axe stop marks on the starboard bow of the Kentmere 1 dugout base, and the implied mode of use of the medium sized, thin-bladed tool. B) Diagram showing the disposition and character of chisel marks surviving underneath the lead tingle inside the lower part of the stern of Kentmere 1.



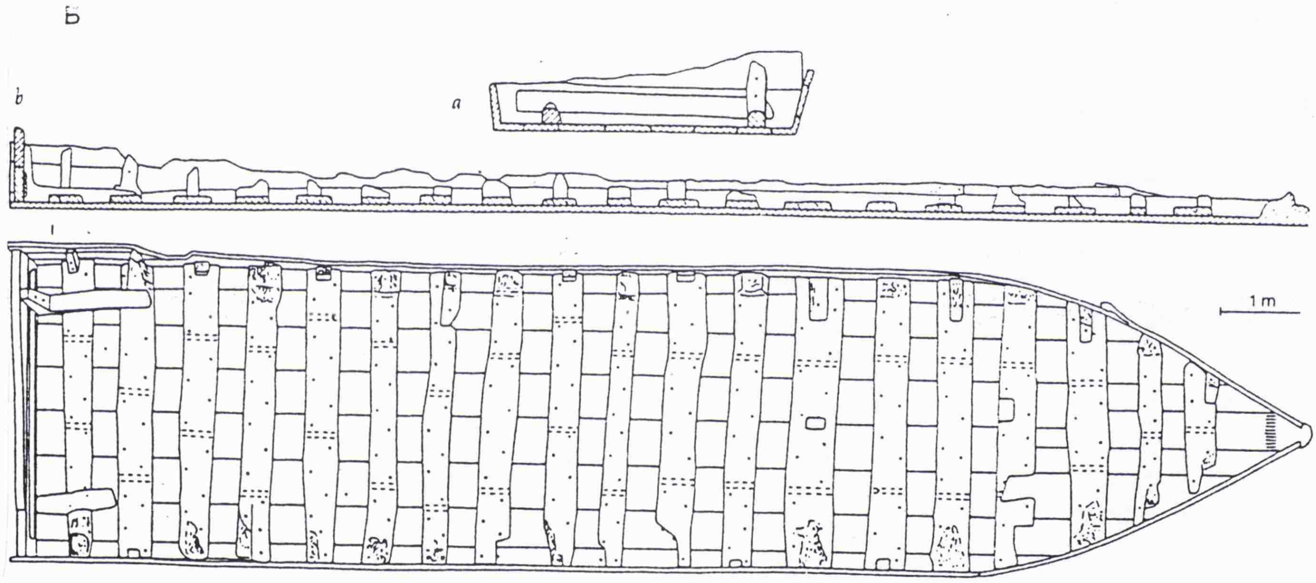


Fig. 66 A) The lead tingle (patch) used to repair the inside of the stern of the Kentmere 1 boat. B) One of the C14th flat bottomed Flasterbo boats (after Ellmers 1972).

BEFORE & AFTER SPREADING A COAST SALISH CANOE

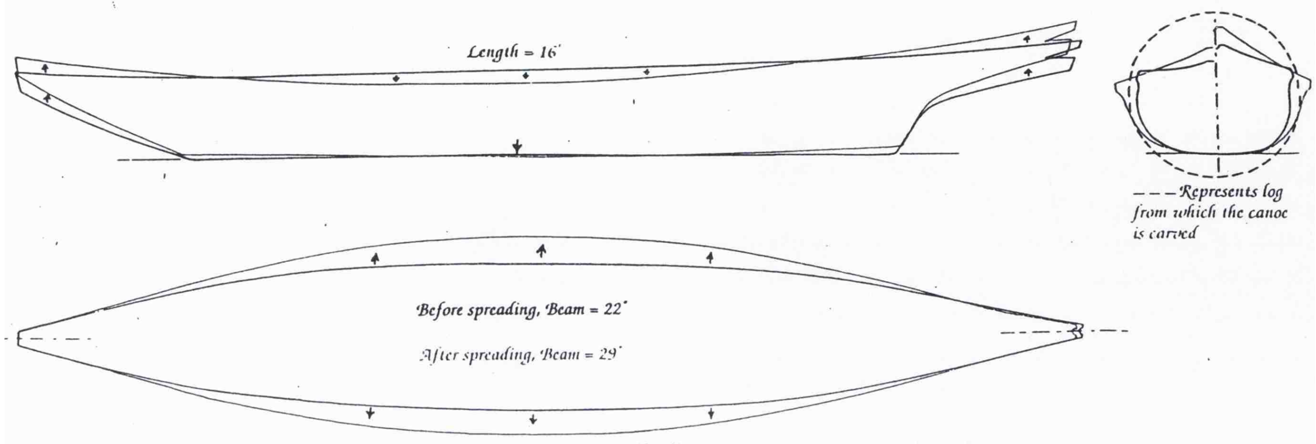


Fig.67 Diagram to show effects of expanding a dugout, in this case from the NW coast of N. America; after Lincoln 1992 p28.

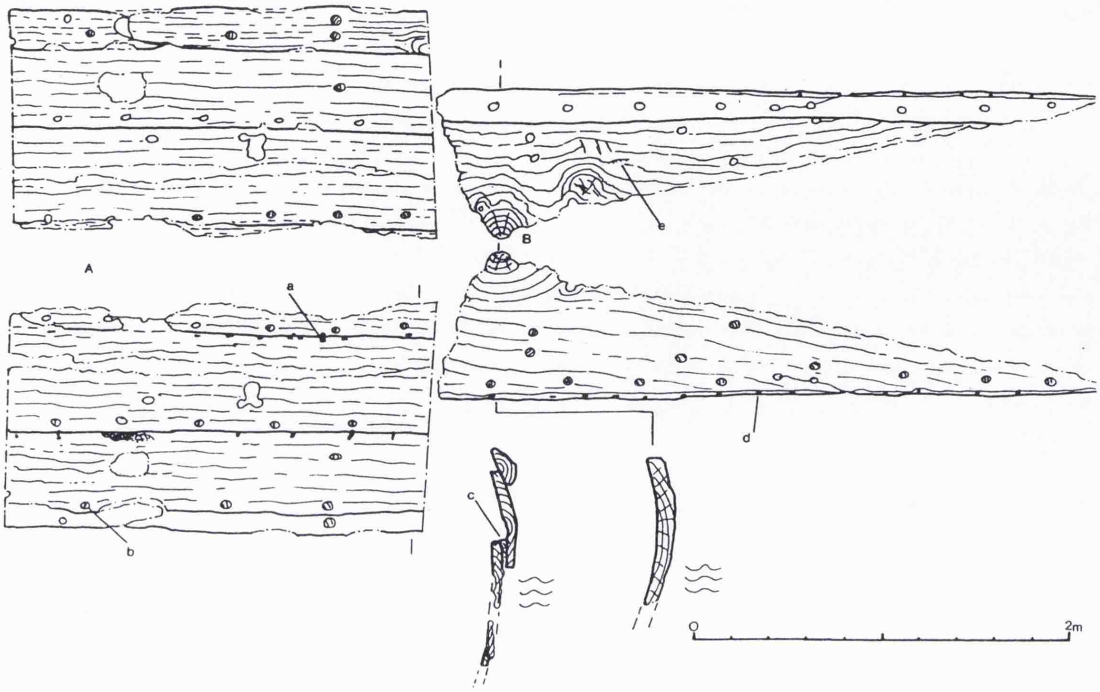


Fig.68 Reused timbers from a 10th century seagoing vessel of Low Countries origin, found at UPT90, London. A) Section of upper hull planking, outboard face top. B) A section of dugout hull bottom, outboard face top. Details; a, iron sintels; b, oak wedged willow or poplar treenails; c, iron sintel holding down a lath over moss caulking; d, sintel fragment; e, adze stop mark.

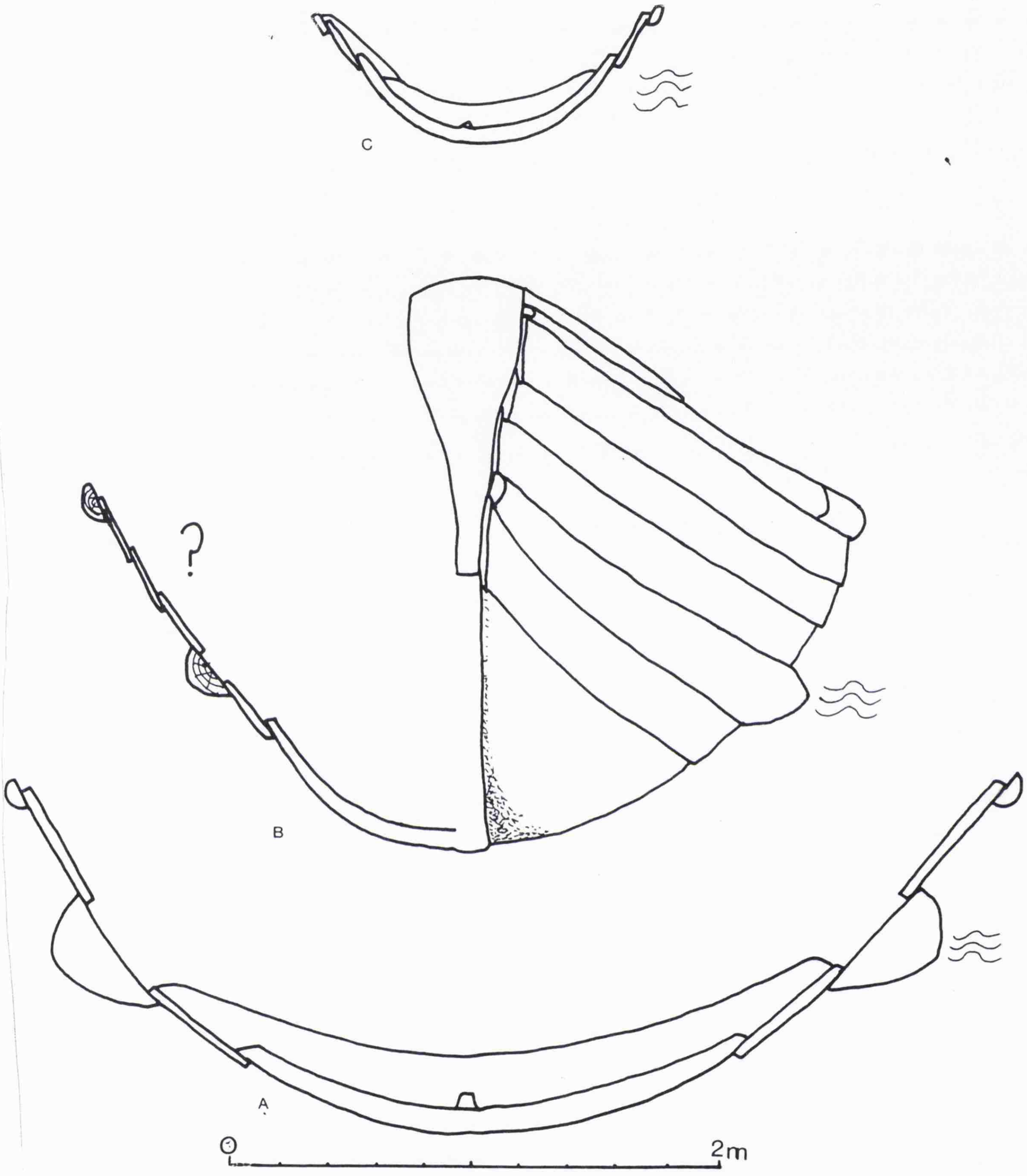


Fig.69 Diagramatic cross sections of three early hulk type craft. A) The Utrecht 1 ship, after Vlek 1987, Fig.6.2.4. B) A hypothetical reconstruction of the parent expanded and extended dugout vessel from which the Frisian boat timbers found at UPT90 and BUF90 derived. C) The small expanded and extended dugout vessel from Velsen, after Vlek 1987, Fig. 6.2.4.

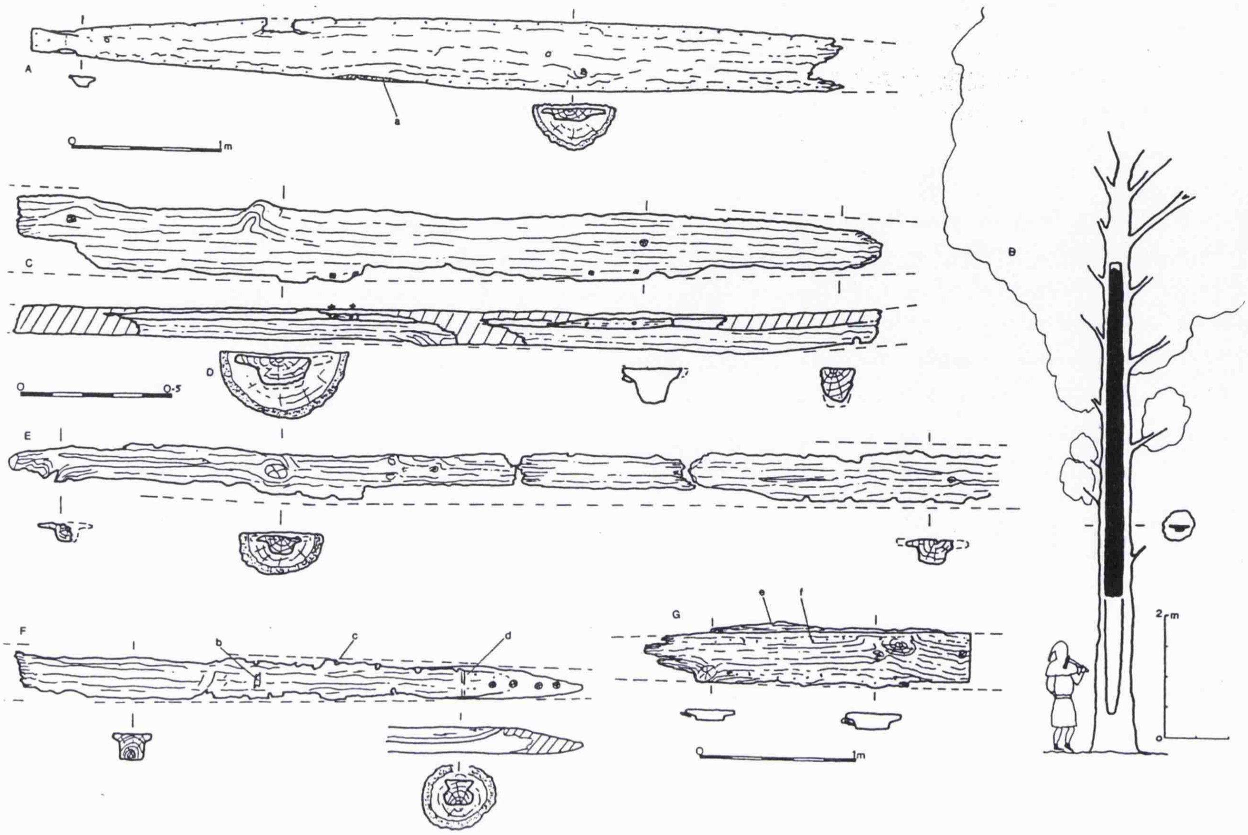
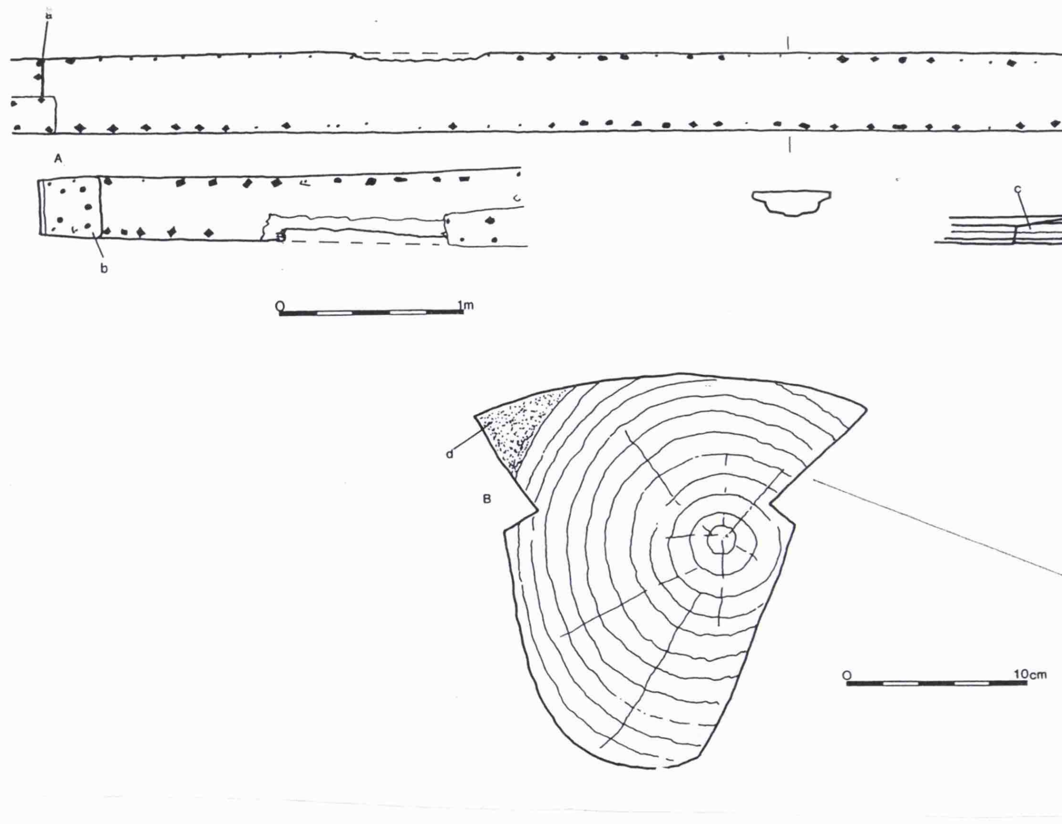


Fig.70 Pre-Norman Conquest keels from England. A) The keel of the Graveney boat from N. Kent, after McKee in Fenwick ed. 1978, B) A reconstruction of the parent oak used for the Graveney boat keel. C) The best preserved after section of the 10th century reused keel [2413] from TEX88, London. D) A reconstruction of the parent half log for TEX88 [2413] keel. E) The best preserved section of the eroded 10th century keel [5656] from VRY89, London. F) The smaller early 11th century keel [5714] from VRY89. G) The 11th century reused keel from FW84, London. Details; a, sapwood; b, incut marks from the ship breakers axe; c, a nail plug hole; d, two scratched lines, marking limit of stem timber; e, flange for the garboards; f, the turned over inboard ends of the iron nail garboard fastenings. The Magor Pill keel parent tree after Nayling et al 1998 to right.



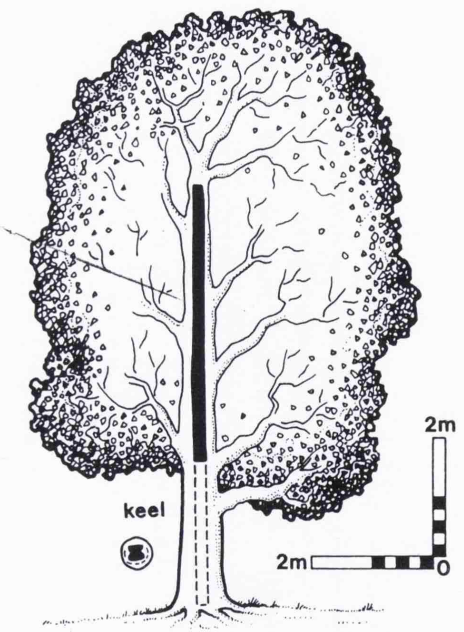


Fig. 71 Medieval keel timbers. A) The two piece keel of the Blackfriars 3 boat of c. 1400 AD, London (redrawn from Marsden 1996, Fig. 139.). B) Cross section of the keel of the mid 13th century Magor Pill boat, SE Wales. Details; a, the stop-splayed keel scarf; b, the stop-splayed keel to stem scarf; c, the keel scarf side view.

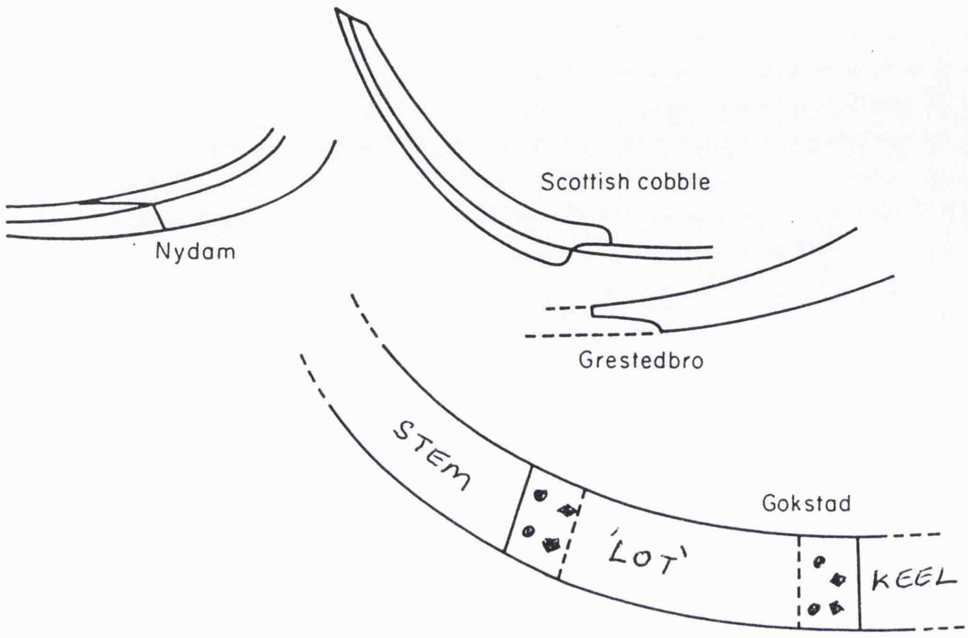


Fig. 72 Two broad types of early medieval keel stem scarf. Horizontal types top, typical of most later English forms. Vertical forms bottom with intermediate 'lot' timbers, typical of later Scandinavian work (after Goodburn 1986, Fig.2.).

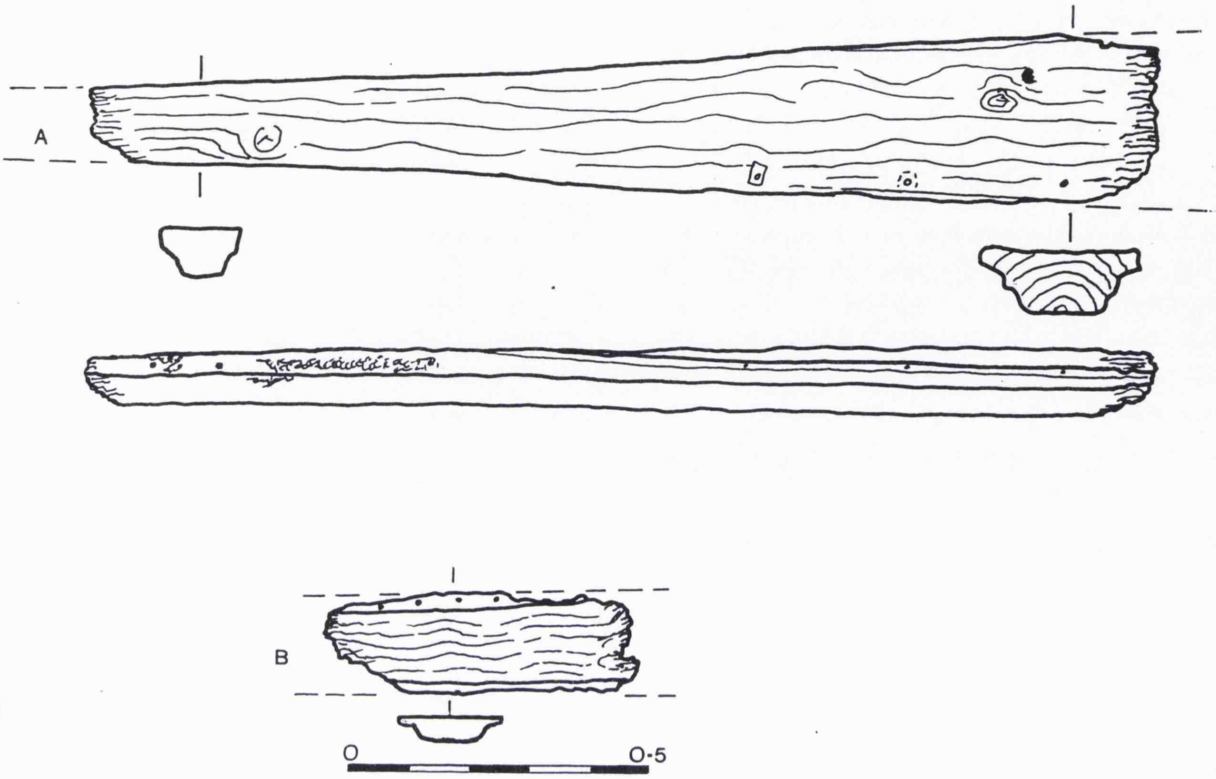


Fig. 73 Sections of two early Post-Medieval keels from clinker built vessels. A) The late 16th century elm keel end [320] from MGS96. B) A lifted section of the elm keel of the Blackfriars 2 boat (redrawn from a photograph, Fig. 141, in Marsden 1996).

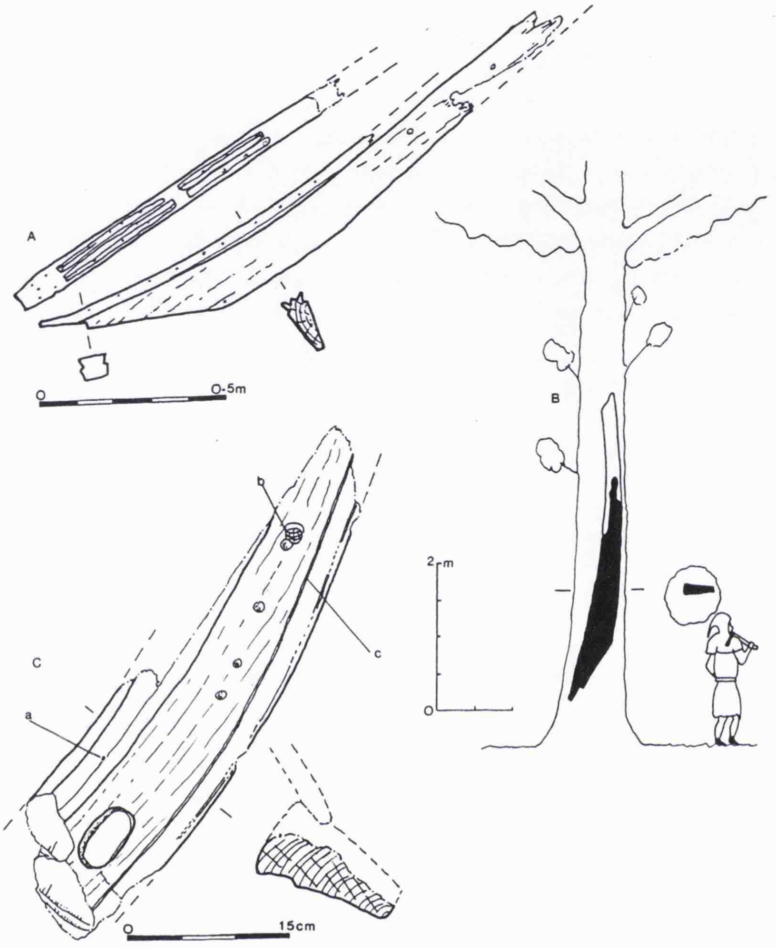


Fig. 74 Pre-Norman Conquest stem timbers from England. A) The after stem of the Graveney boat, N. Kent (redrawn from McKee 1978, Fig. 3.2.2). B) Hypothetical reconstructed parent oak for the Graveney after stem. C) The 10th or early 11th century stem fragment [5015] from VRY89, London. Details; a, iron nail shank in rabbet for plank ends; b, oak treenail; c, two line scratched moulding.

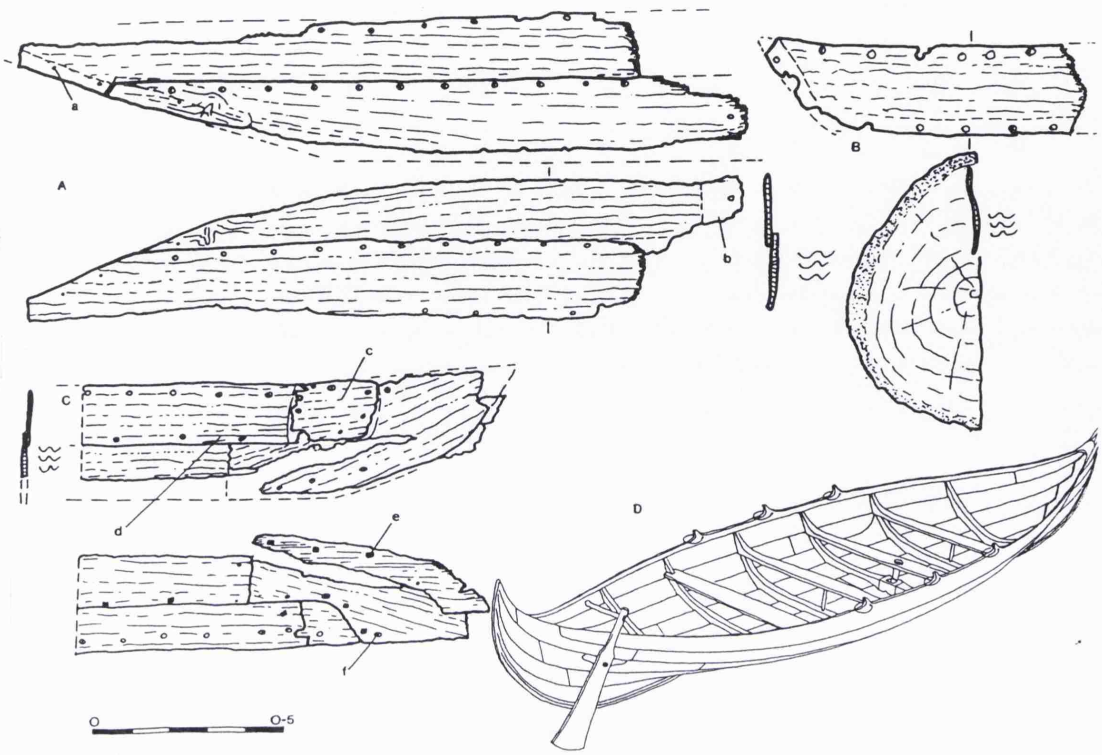


Fig. 75 Pre-Norman Conquest planked vessel end forms, some evidence from London. A) Straight raking hood end boards, ([7250] etc.) from the port side, stern of an early 10th century vessel, UPT90. Treenail fastened. B) A curved 10th century, treenail fastened, hood end ([2412]), TEX88. With a reconstructed parent half log. C) Curved hood ends ([7469] etc.), from the starboard side bow of a small early 10th century vessel, UPT90. D) A reconstruction drawing of the small 12th century boat from Gislinge, Denmark (after Gothche 1993).

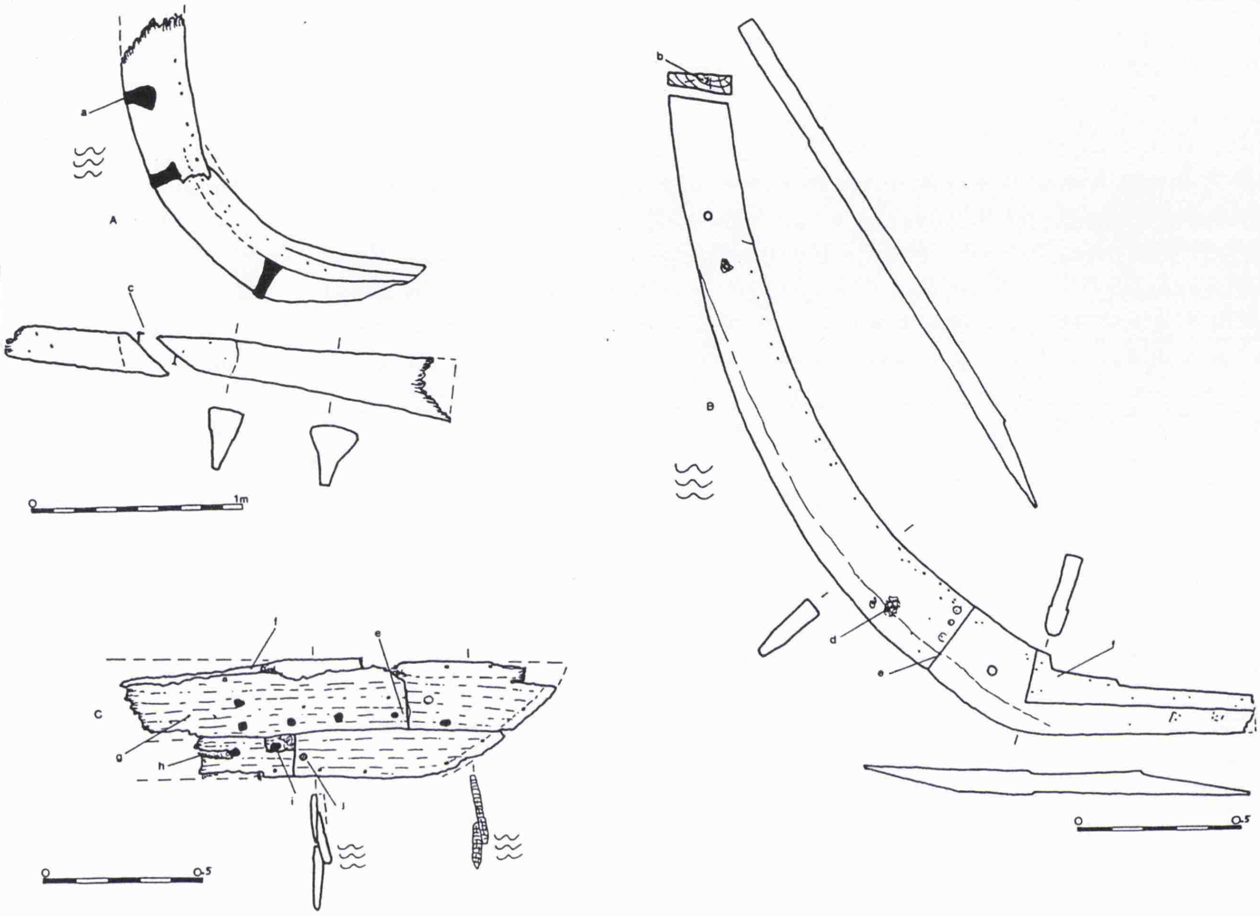


Fig.76 Some medieval stem timbers and hood ends from England. A) The two piece after stem of the Blackfriars 3 boat of c. 1400, London (redrawn from Marsden 1996, Fig.43. B) The stored, used, 15th century two piece stem from Poole Iron foundry, Dorset (redrawn from Hutchinson 1994, Figs. 27-28). c) The early 14th century curved hood ends ([529] etc.) of the Kingston 1 boat, London. Outboard face, port side, stern. Details; a, iron fitting probably part of a broken stern rudder hanging system; b, iron nail shank; c, iron stem scarf nail; d, iron concretion round nail; e, stop-splayed scarf; f, inboard tingle; g, turned iron tingle nail tip; h, tarred hair scarf luting; i, iron rove nail head; j, willow or poplar treenail.

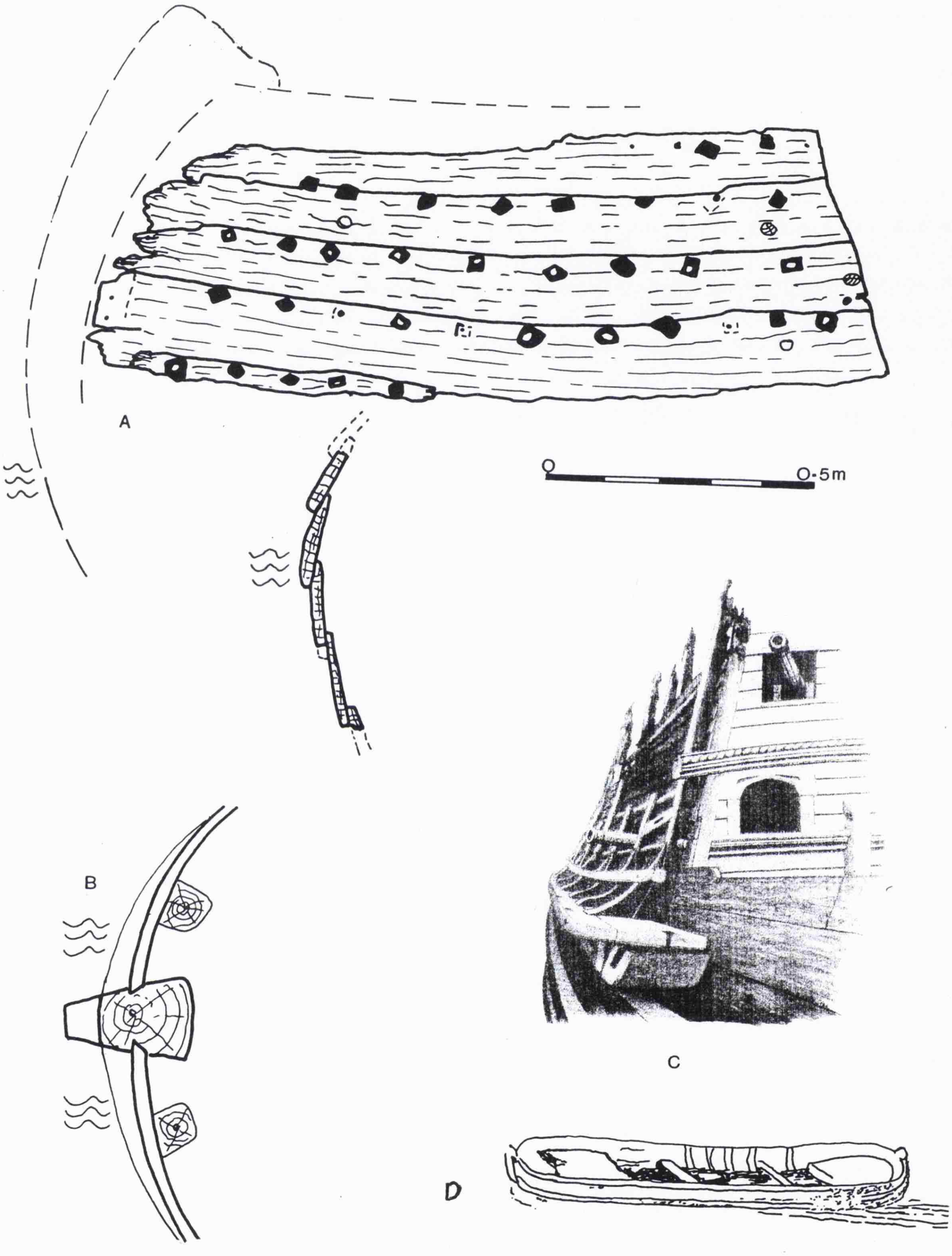


Fig. 77 Alleged reverse clinker planking from London of 16th century date. A) Inboard face of an articulated slab of oak clinker planking with traces of the surface joining the stem rabbet, from MOR87 (redrawn from Marsden 1996, Fig. 130 and authors own field notes). Approximate outline of suggested stem shape and sheer line dashed. B) Suggested plan view of end of parent vessel, an 'apple cheeked' lighter or barge of some form. C) Alternative source in ship; reconstruction of part of upper works of Mary Rose after Rule et al 1986. D) Images of 'apple cheeked' clinker built lighters from the Hollar Thames panorama of 1647 (Redrawn from Marsden 1996, Fig. 153).

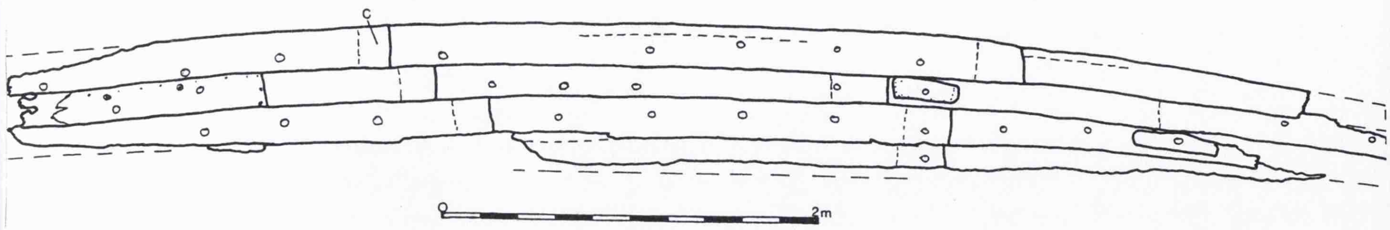


Fig. 78 The largest section of articulated hull planking from the early 14th century Kingston 1 boat, HOR87. Both ends were damaged in situ by amateur archaeologists and contractors machines. The slab is from the port side (outboard fishes eye view) and was most of the bottom planking. Details; A) towards the bow; B) towards the stern; C) location of original board scarfs. Open circles are treenails or treenail holes, lap fastenings not shown. Compiled from corrected site elevation drawings, 1:1 tracings and authors notes. Further detailed work may eventually revise the reconstructed shape very slightly. The keel would have lain roughly along the line of the scale bar.

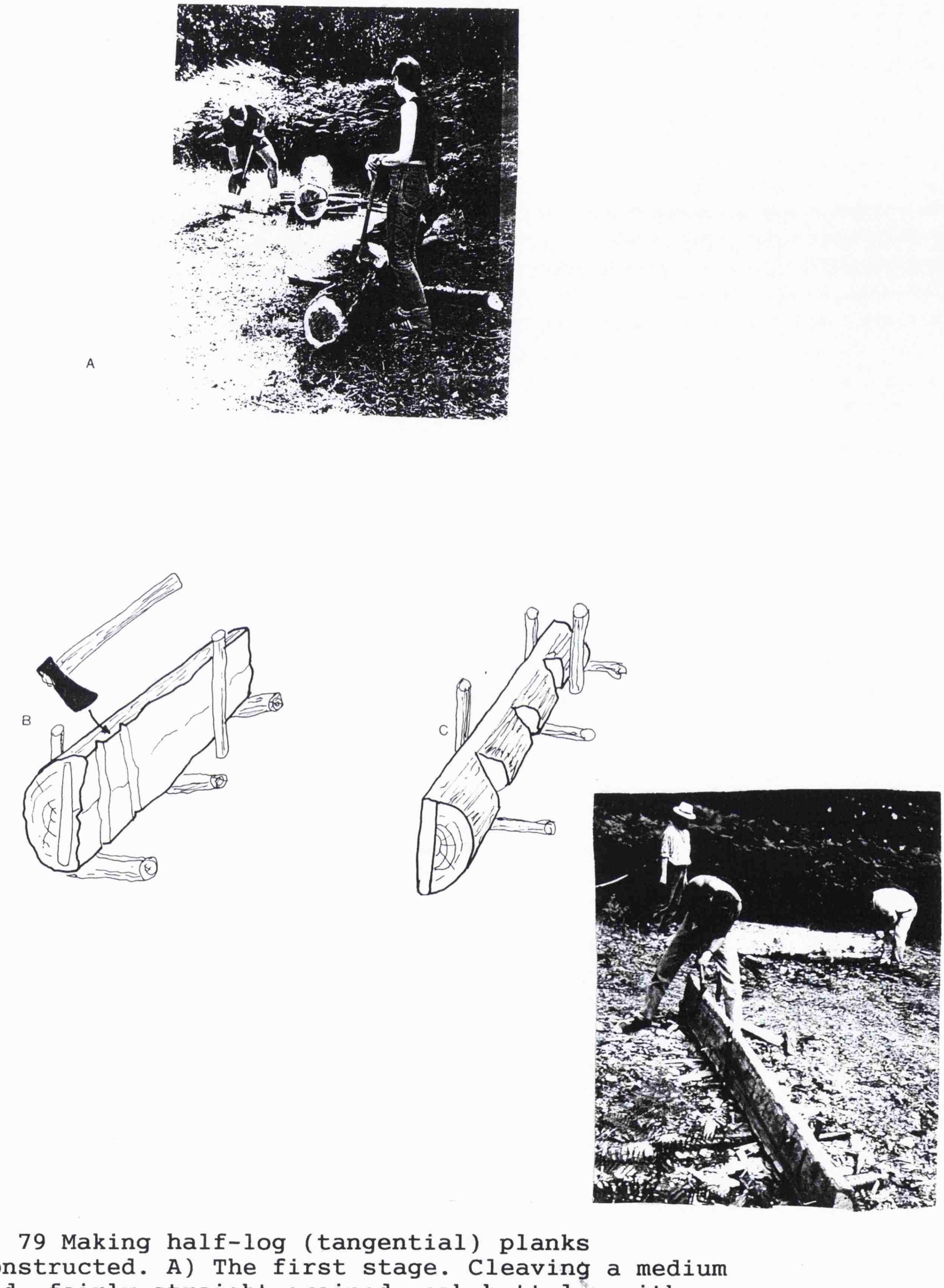


Fig. 79 Making half-log (tangential) planks reconstructed. A) The first stage. Cleaving a medium sized, fairly straight grained, oak butt log with hardwood wedges and a wooden maul . B) Diagram showing, scoring and hewing required to trim the cleft heart face. C) Diagram showing the scoring of the waste bark face prior to splitting and hewing it off. Cross section of the finished tangentially faced plank marked on half-log end. D) Hewing the heart-face of a half-log plank.

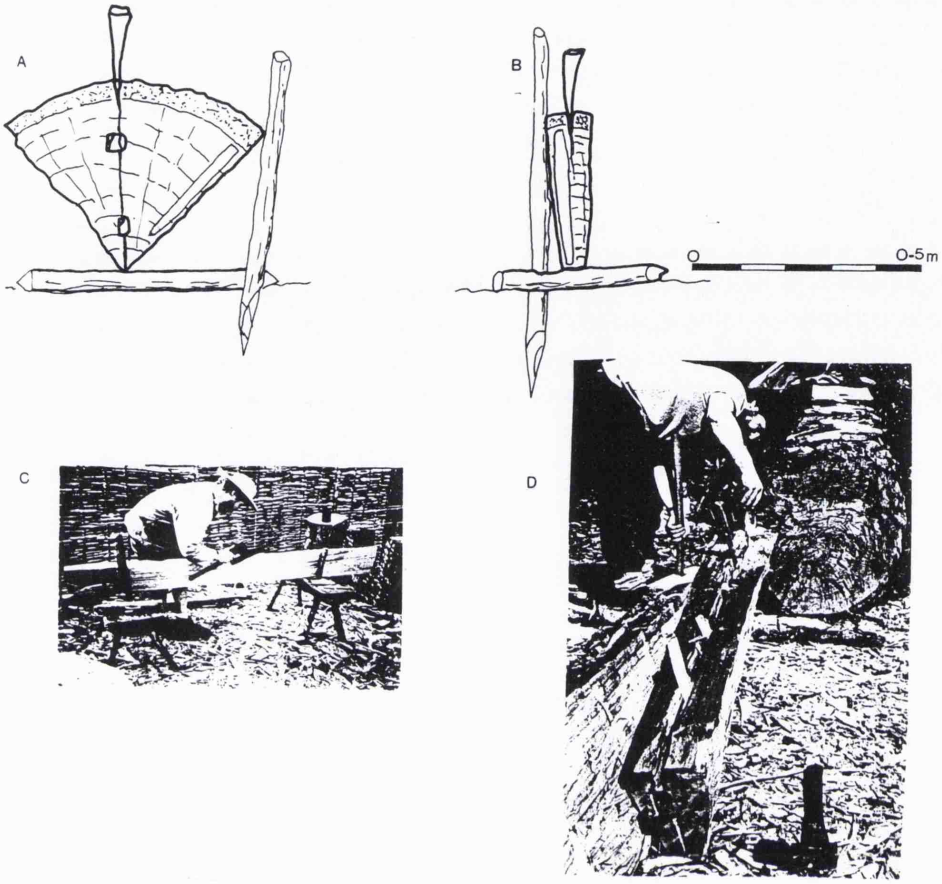


Fig. 80 The production of radially cleft oak ship board reconstructed. A) Diagram showing cross section of typical cleft 1/4 log section. B) Diagram showing cross section of a cleft 1/16th, with the feather edge and knoty pith hewn off prior to the final cleaving into 1/32's. C) Trimming a freshly cleft rough oak ship board with a broad axe of early medieval type. The relatively small proportions of the board are typical of the 16th century. D) Cleaving a 1/16th cleft section into two even 1/32nd sections with wooden wedges, and a wooden maul (Photo. V. Fenwick).

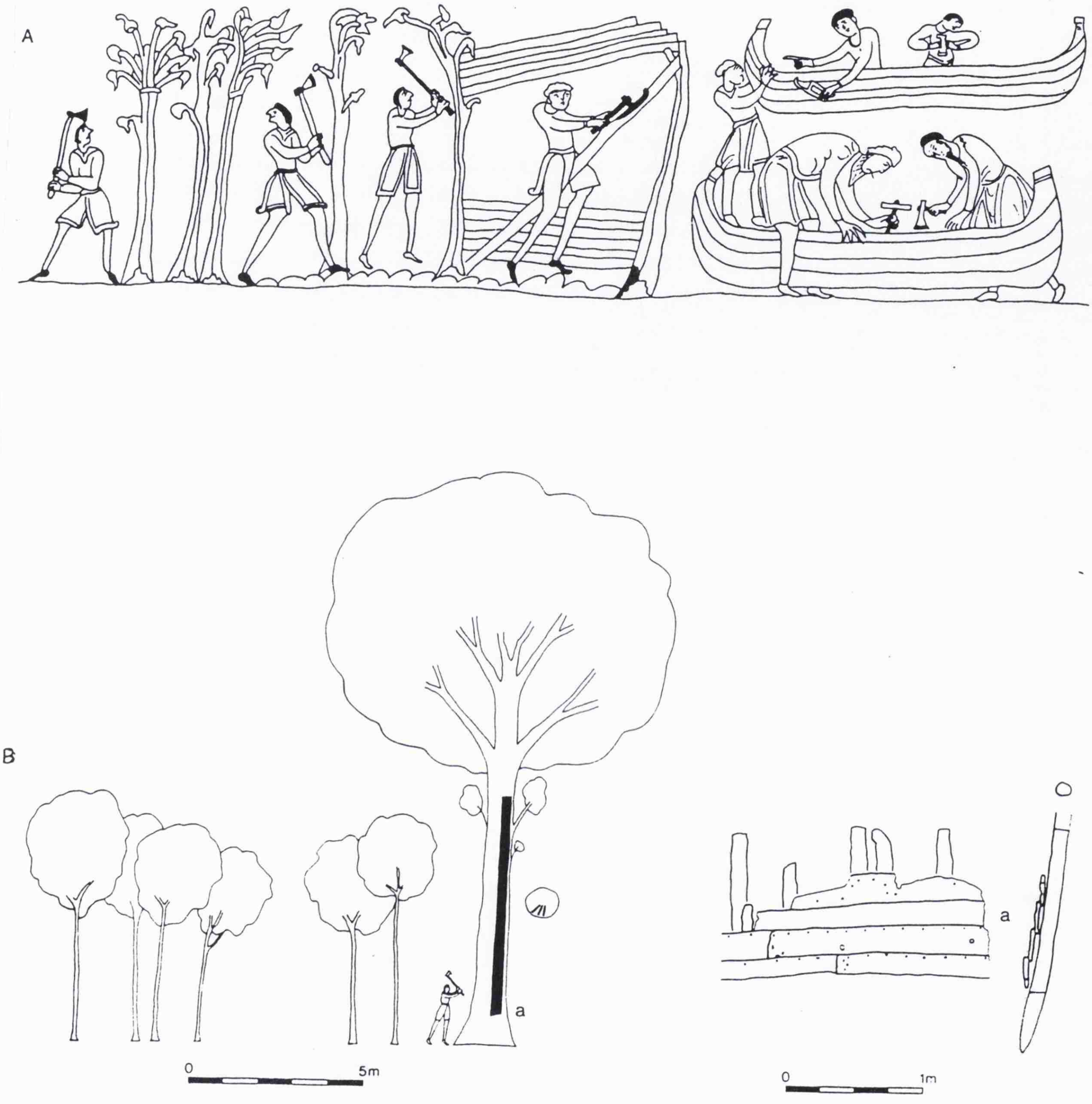


Fig. 81 The Bayeux Tapestry shipbuilding scene, and reconstructed early medieval wildwood 'board' trees. A) A scene from the Bayeux Tapestry showing tree felling, board hewing and building clinker ships. Not included are the essential stages of cleaving the ship board. B) A reconstruction of a typical early medieval wildwood oak suitable for making contemporary ship boards, as shown reused in a late 10th century river wall from London, TEX88 (after Goodburn 1992, Fig. 105).

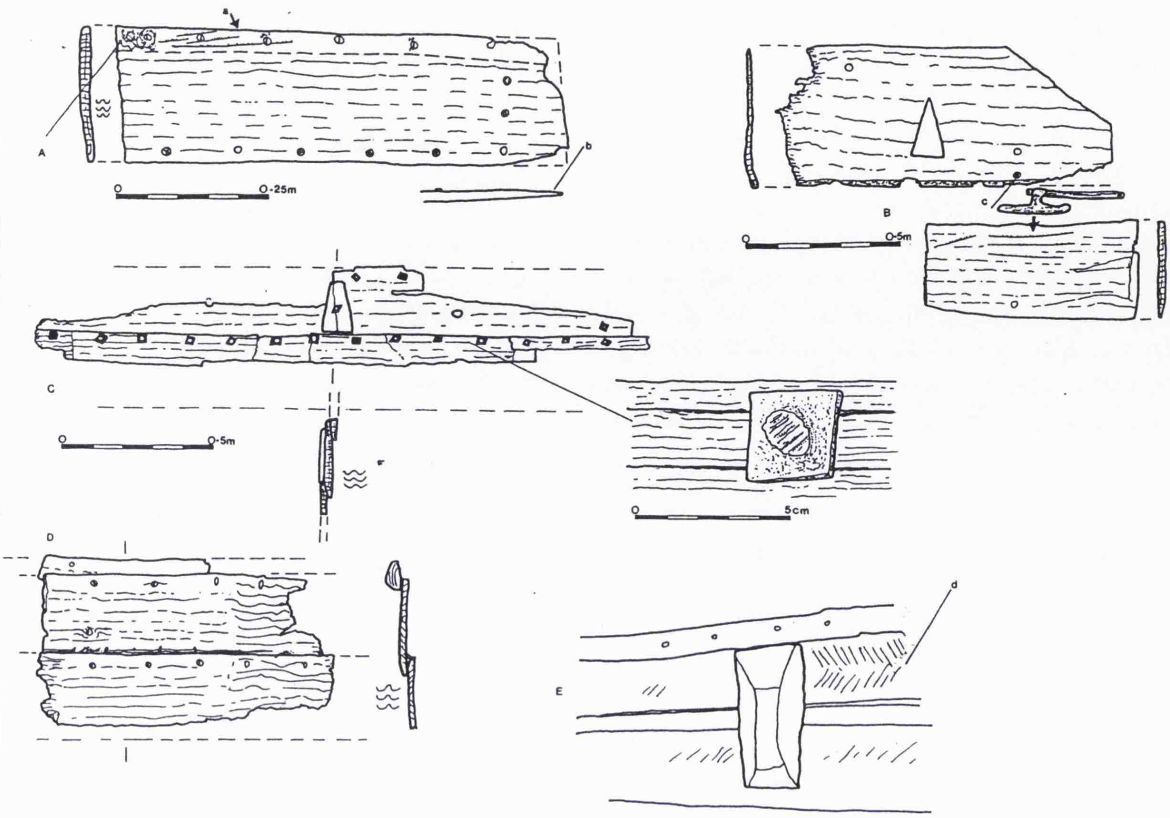


Fig. 82 Typical pre-Norman Conquest hull boards, and comparative material. A) A radially cleft 10th century oak clinker hull board ([5732]), with treenail fastenings, TEX88. B) Two typical radially cleft oak 10th century house clapboards. The uppermost with a triangular window, UPT90, London, the lower example [5256], CID90, London. C) Scandinavian style hull planking ([5484] etc.) and attached frame or cleat fragment, Inboard face, and detail of double scratched moulding and chisel peine

hammer marks on the clenched rove nail end, VRY89, London, c. 1000AD. D) A section of 10th century ash and oak 'Frisian' boat, upper hull planking and rubbing strip ([7363] etc.) UPT90, London. Inboard face. E) Diagram, not to scale, part of the inboard face of upper planking in the 11th century Skuldulev 3 vessel (drawn from photograph, Crumlin-Pedersen 1986, Fig. 15 photo.). Detail; a, the arrow shows the direction of use of the large bladed broad axe that was used to trim the laps, leaving the long straight stop marks; b, short treenail fastened scarf; c, Willow or poplar headed treenail-like peg; d, distinctive hering bone pattern axe stop marks.

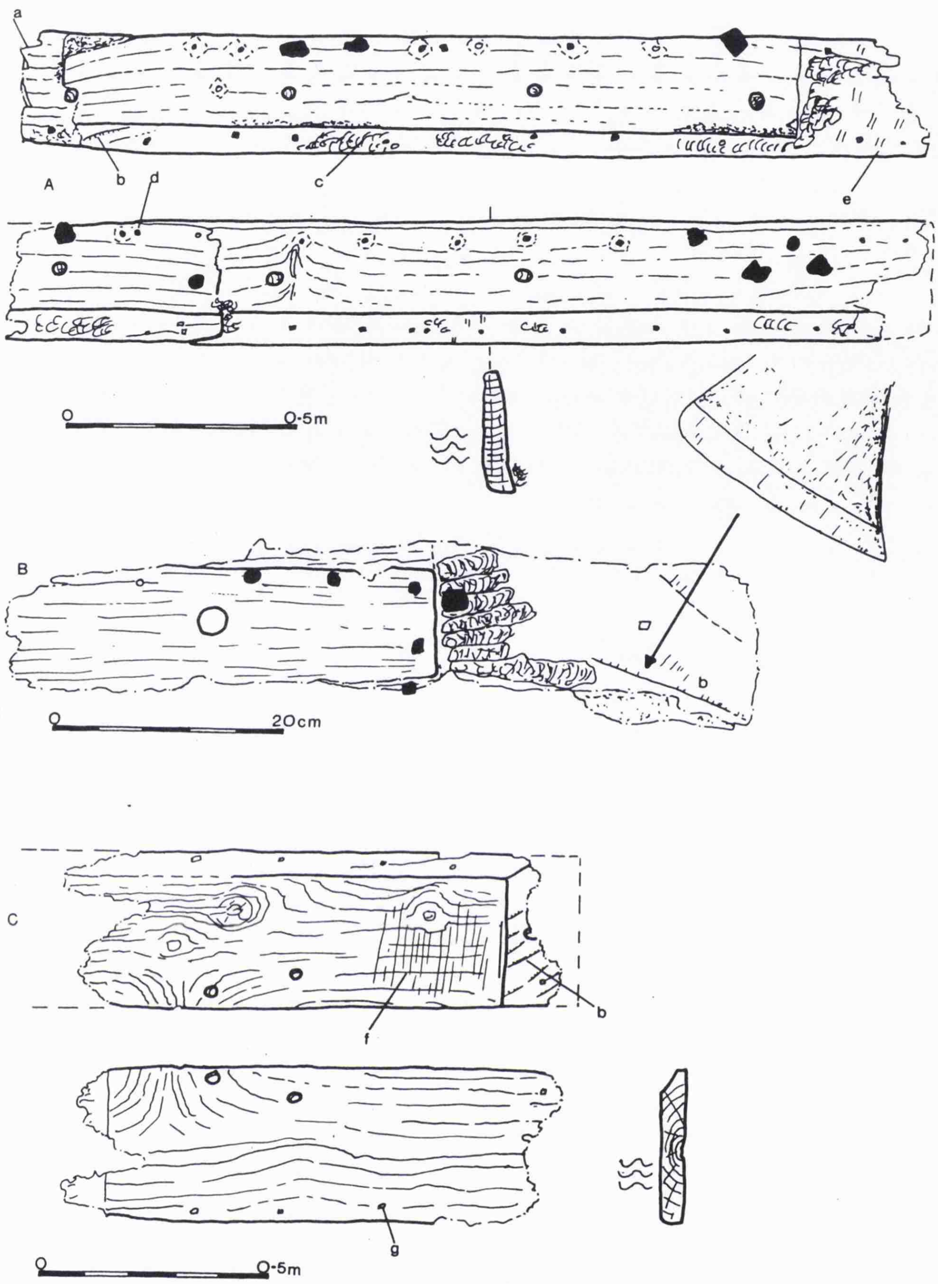


Fig. 83 Selected later medieval hull planking with clear tool marks. A) A c.14th century radially cleft oak board ([5304]), ABO92, London. B) A small section of radially cleft oak board ([509]) with a tingle and part of an original scarf from the Kingston 1 boat, c.1300. Scarf luting rolls of tarred animal hair. C) A section of sawn oak hull plank ([85]) from a vessel built in the cog style, 13th century, PLS94, London. Details; a, board end cut by ship breaker; b, incomplete axe stop marks- 120mm wide top board, 140mm wide middle board, 100mm wide bottom plank; c, tarred animal hair luting in lap; d, oak nail hole plug; e, striations caused by nicks in the axe blade used to cut the scarf; f, clear saw marks; g, lap nail hole for clinker seam.

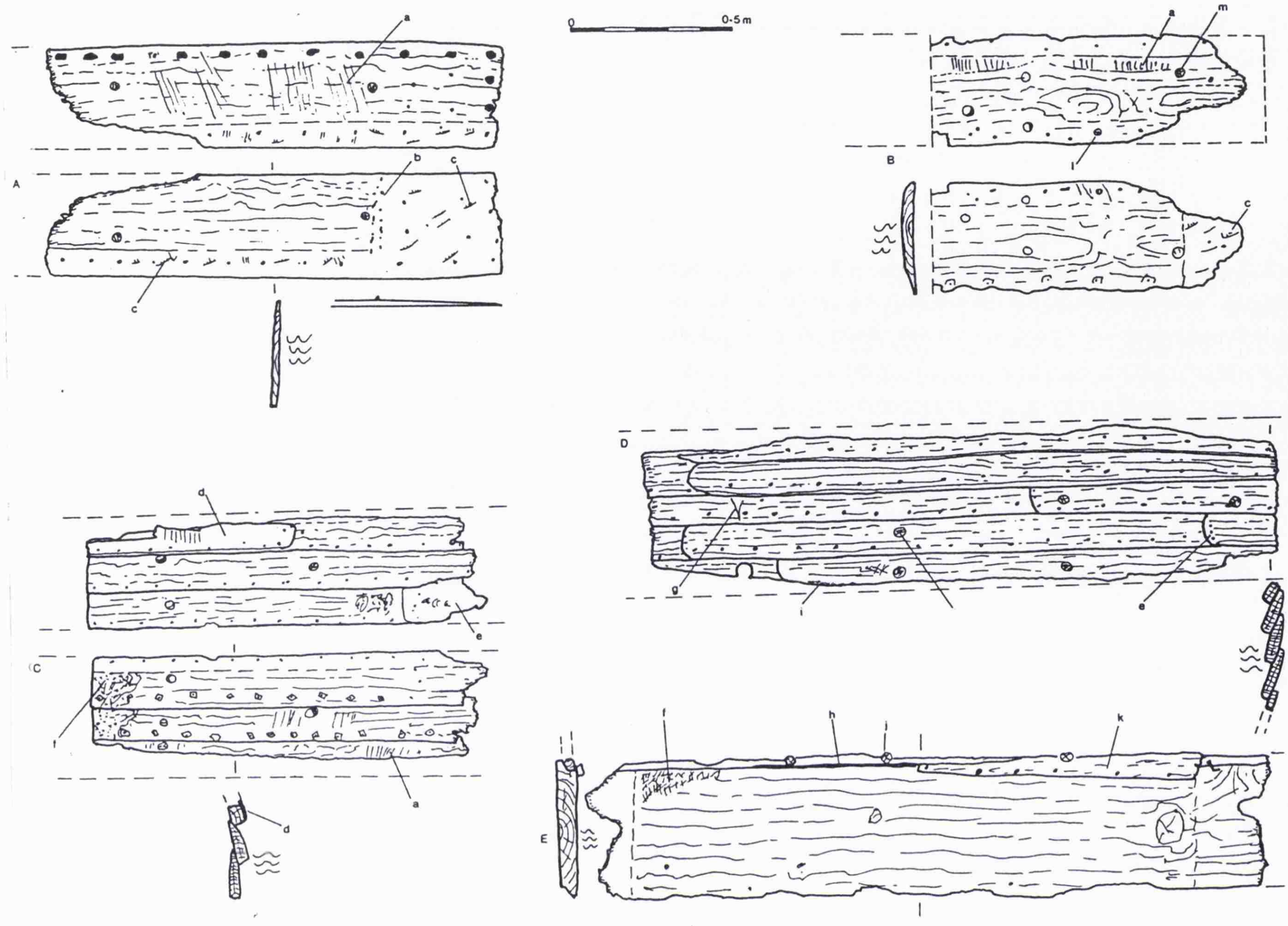


Fig. 84 Toolmarks on early post-medieval clinker boat planks found in London. A) Sawn elm plank of c. mid 16th century ([34]), MOR87 (drawn from authors notes and Marsden 1996, Fig. 167). B) Very similar sawn elm plank ([408]) of 16th to early 17th century date, VIY97, London. C) Articulated slab of mixed sawn and radially, cleft, oak clinker planking ([538]) of c. early to mid 17th century, BEY95, London. D) Articulated slab of very narrow, radially cleft oak clinker boat boards ([302] etc.) JAC96,c. 1600, London. Outboard face. E) A section of sawn oak vessel planking with unusual rabetted laps ([5126), ABO92, London, mid. 16th century. The dashed area was cut for reuse. Details; a, clear manual saw marks; b, small corroded iron tacks used for fastening the scarf ends; c, incomplete adze or axe stop marks; d, sawn elm tingle; e, hewn scarf face; f, cream coloured deposit (probably white lead paint); g, a scratched reference mark; h, small oak seam lath; i, sapwood left on; j, large facetted iron rove nail head; k, oak tingle; l, willow or poplar nail hole plug; m, oak treenail; n, oak treenail with central wedge or 'dottel'.

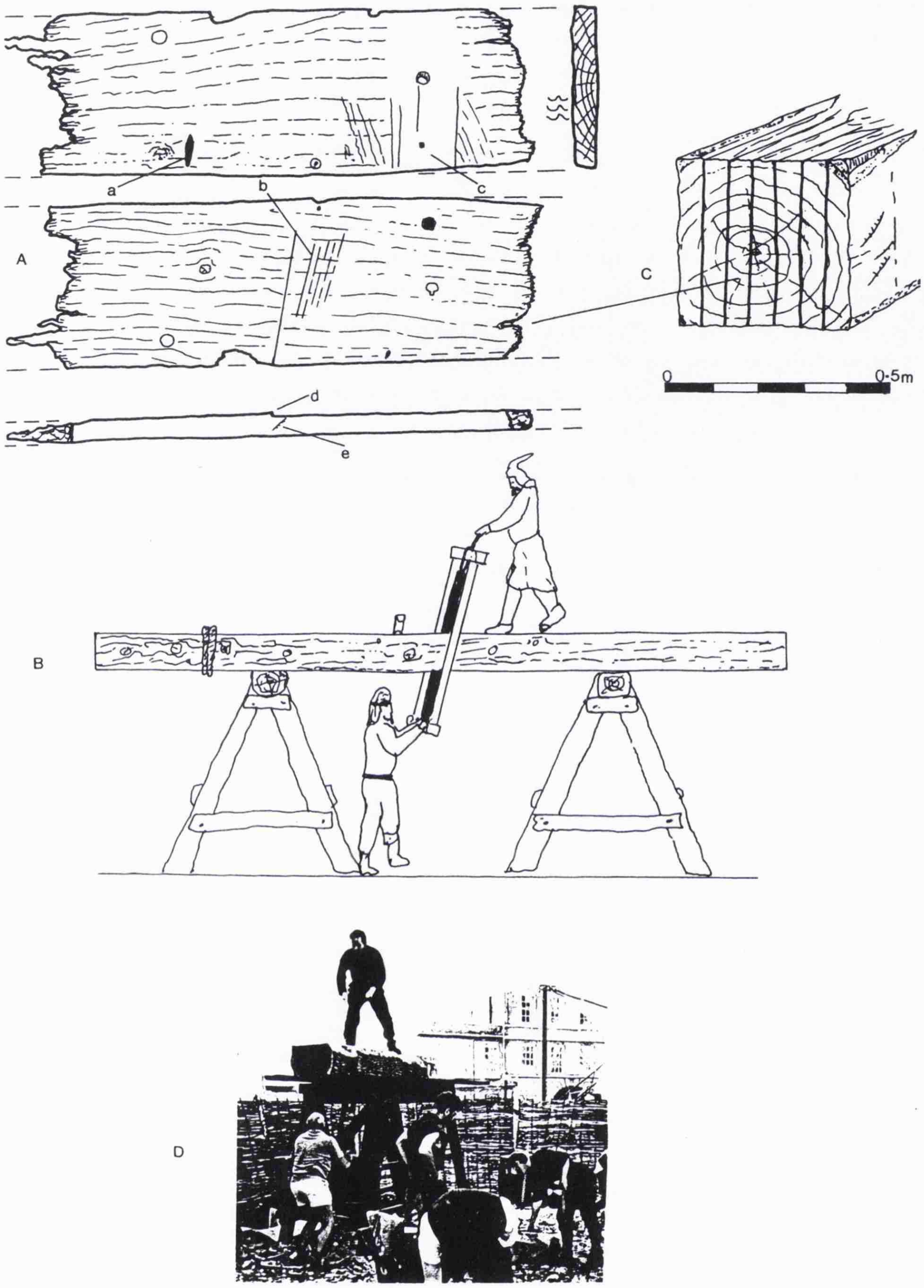


Fig. 85 Some sawn medieval cog-type planking and how it was produced. A) A sample of c. early 13th century double trestle sawn, oak, cog bottom planking ([84]), PLS94, London. B) The double trestle sawing method reconstructed. C) The hewn parent saw baulk, reconstructed. It would have probably produced 6-7 sawn planks. D) Experimental double trestle sawing, Portsmouth 1995, note edges of baulk would normally have been hewn flat first. Details; a, lamp or taper burn from the building phase of reuse; b, faint saw marks; c, iron spike shank in adze smoothed frame position; d, the 8mm high saw-kerf-join scar; e, faint axe stop mark.

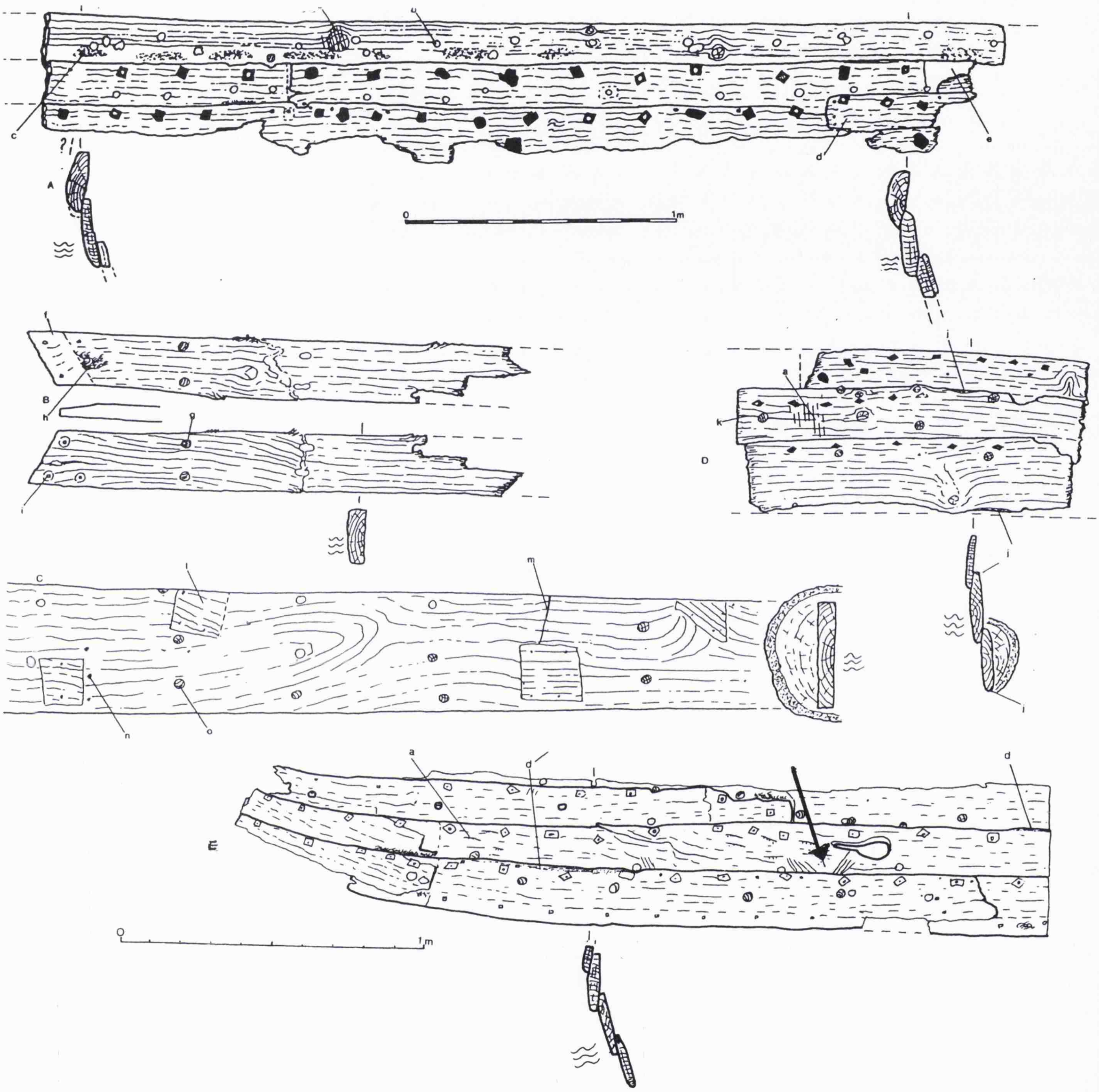


Fig. 86 Manually sawn hull plank elements of medieval and 16th century date. A) Most of the articulated hull slab, of the c. early 14th century Kingston 3 vessel, with a sawn 'D' section. B) A sawn oak hood end plank ([1]) from a c. 1500AD carvel built vessel Camber E. Sussex. C) A section of repaired, 16th century, sawn oak carvel ship plank ([5075]), ABO92. Reconstructed parent log half-section. D) Articulated slab of mixed sawn and cleft oak clinker planking ([315] etc.), MGS96, inboard face. Of late 16th to early 17th century date. Including a reconstructed parent half-log. E) A section of clinker hull planking from the 13th century TYT98 Galley with see-saw mark arrowed. - Details; a, saw marks; b, treenail hole; c, mid-brown tarry deposit- paint? d, cleft oak tingle; e, scarf; adze smoothed bevel for stem rabbet; g, oak wedged oak treenail; h, tarred hair; i, impression of counter sunk iron nail head; j, sapwood; k, the pith; l, an oak patch set flush or 'graving piece'. m, possible saw kerf join scar?.

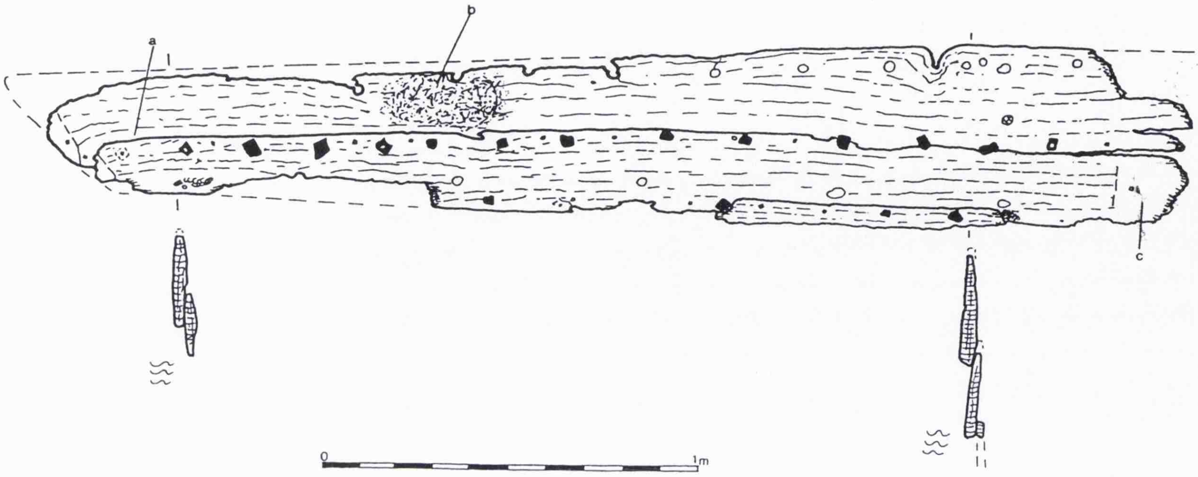


Fig. 87 The Kingston 1 boat probable sheer strake section, with evidence of the use of fire bending, c.1300AD. Details; a, hewn recess to accommodate the hood end below. b, clearly charred area.

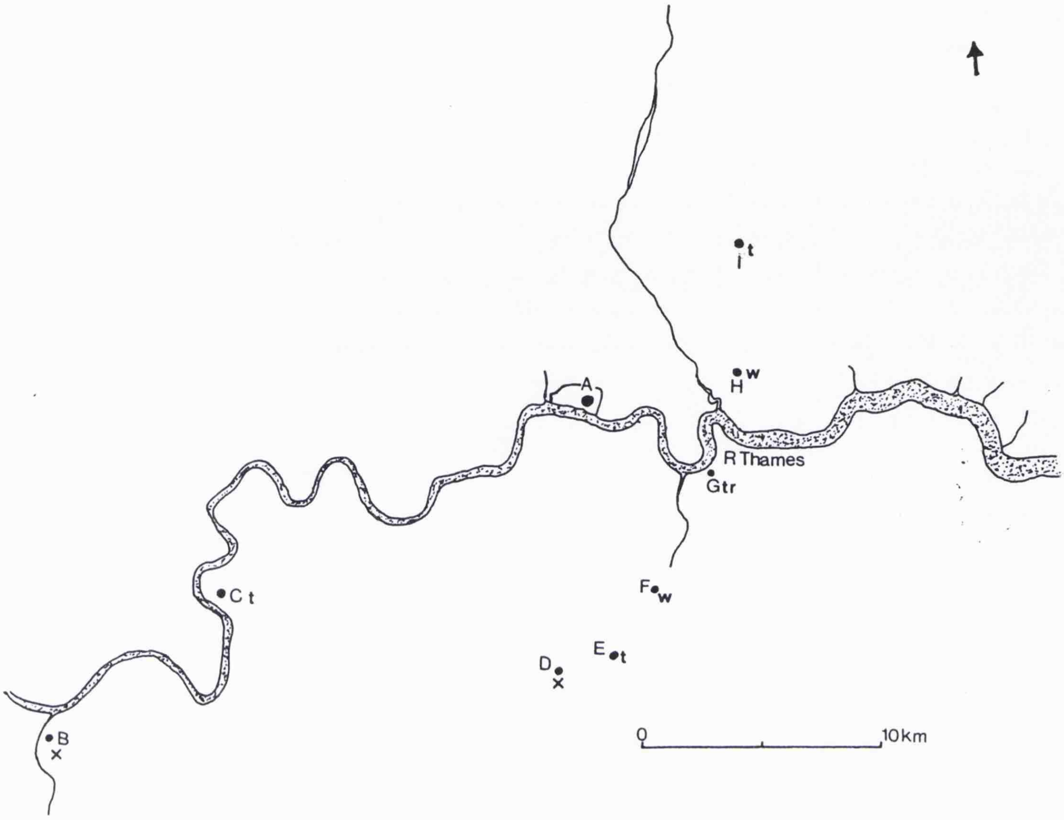


Fig. 88 Some documented sites of timber purchases for ship and boat building projects in later medieval London, (redrawn from Friel 1995:49, and the Bridge House records Marsden 1996). A) London, location of boat and ship yards concerned, B) Weybridge, C) Ham woods, D) Croydon, E) Addington, woods, F) Bekenham Park, G) Greenwich; H) Stratford Abbey; I) Wanstead. Symbols- t = timber, tr = treenail making materials, w = "wrongen and foteken", x = boards.

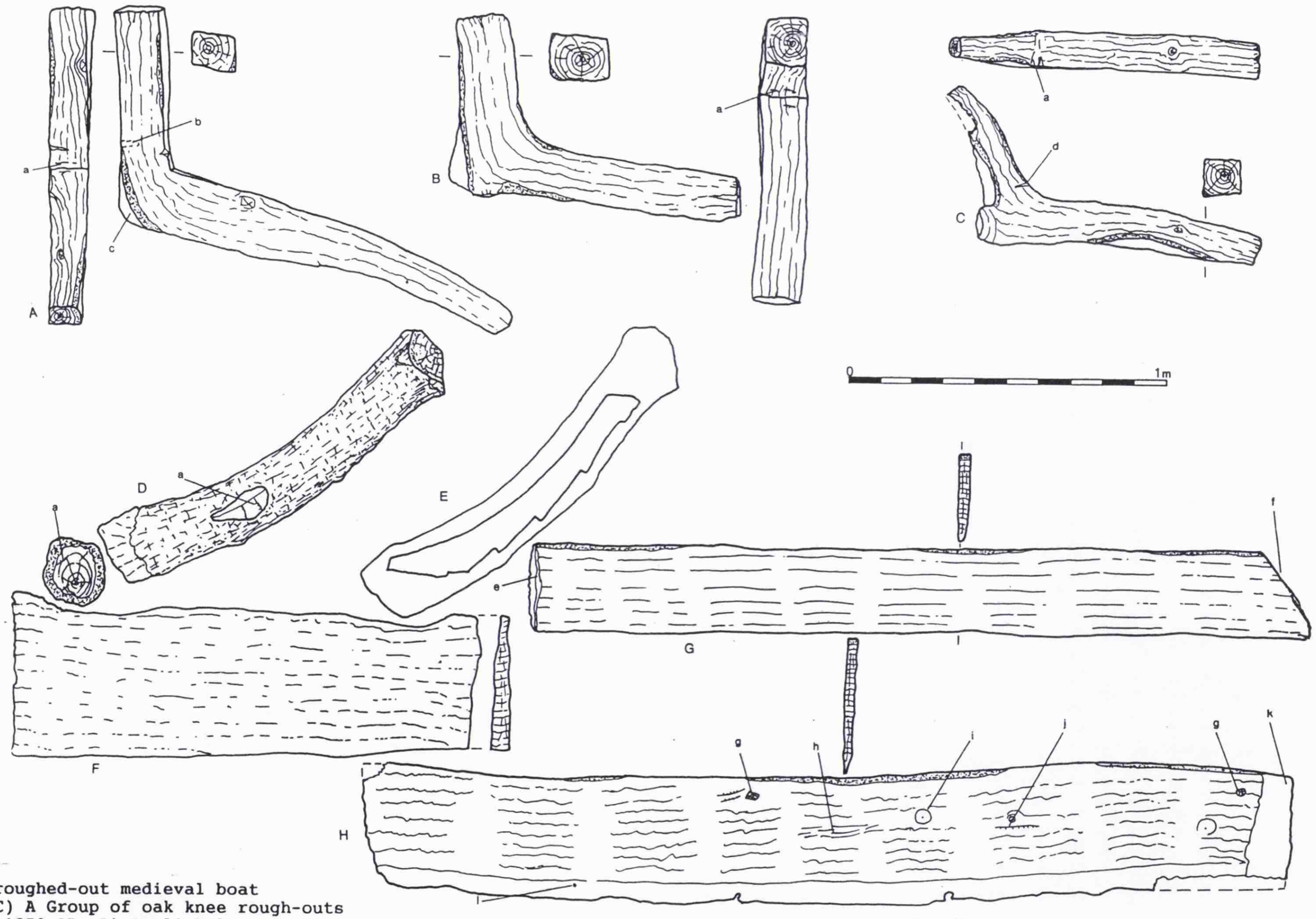


Fig. 89 A selection of roughed-out medieval boat building materials. A),-C) A Group of oak knee rough-outs from Kingston, HOR86, c. 1350 AD. D) A slightly trimmed oak futtock log from Kingston, [106] KIB97, c. 1350 AD. E) The outline of a typical futtock from the Blackfriars 3 vessel and [106] KIB97. F) A roughly trimmed, English, radially cleft oak board offcut, [80] KIB97 c.1350 AD. G) A c.14th century, roughly trimmed, radially cleft, Polish oak export board (displayed in the Polish National Maritime Museum Gdansk). H) A Roughly trimmed, radially cleft, English oak board, used in a riverwall of 1181 AD in London, [7540] BUF90. Details: a) Axe marks; b) Partly drilled spoon auger hole; c) Wane and sapwood; d) Axe overcut; e) Axe bucked end; f) Original felled end?; g) Cleft oak peg; h) Torn grain 'as cleft'; i) Compass scribed merchants mark?; j) A 140mm wide axe stop mark; k) Axe bevelled end; l) Iron nail shank.

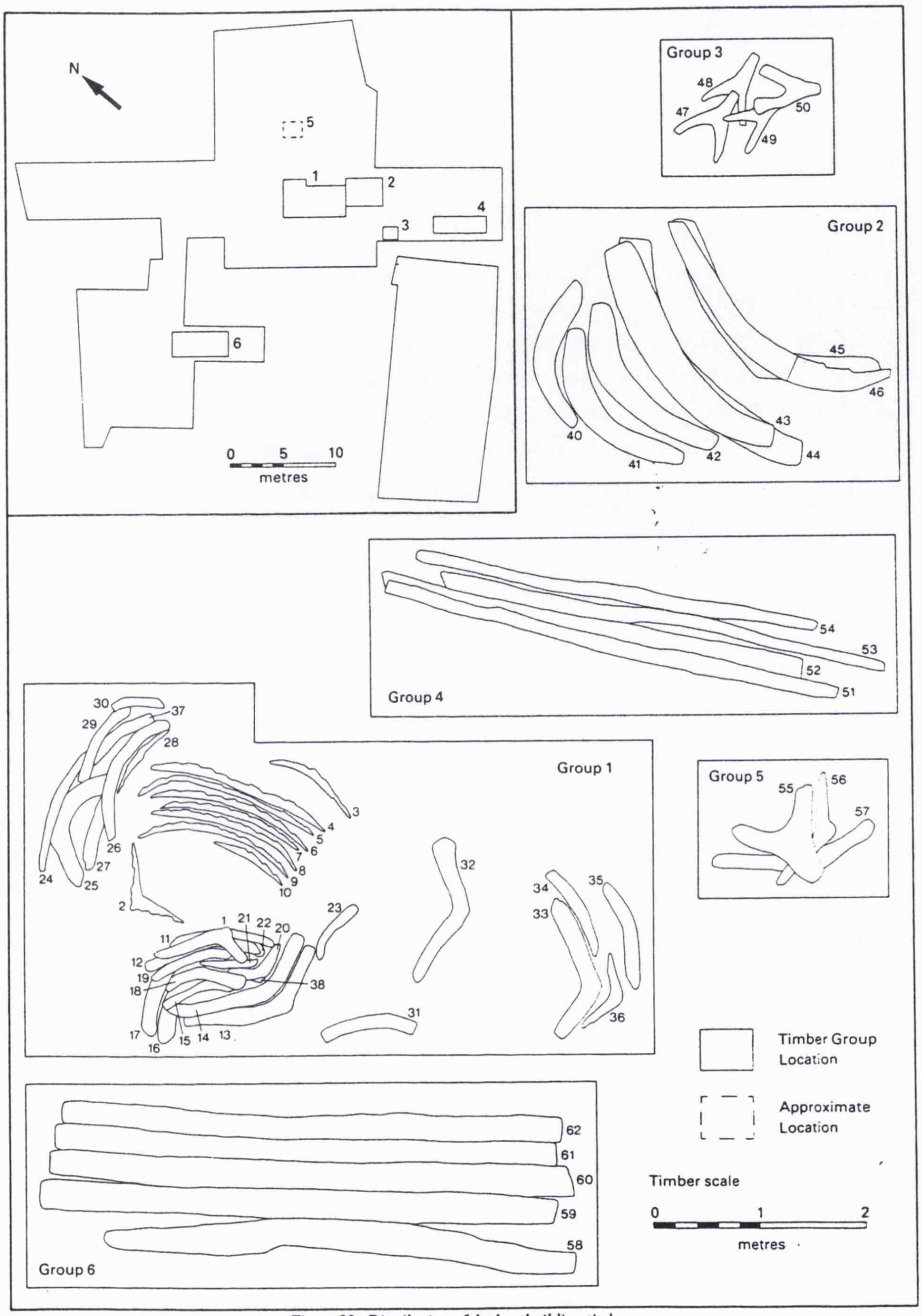
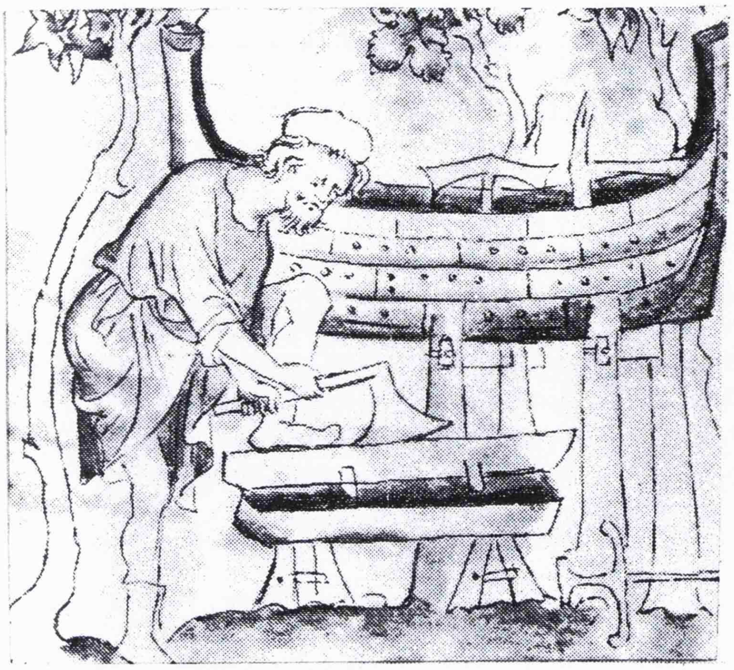
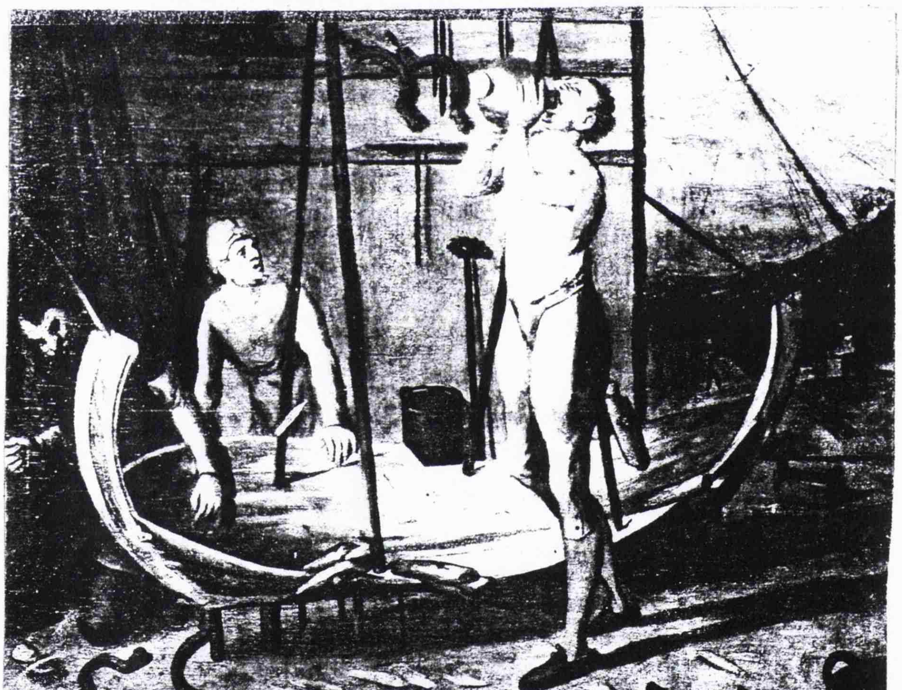


Figure 23. Distribution of the boatbuilding timbers.

Fig. 90 Plans of the timber groups found on the Poole Foundry boatyard timber store site of the 15th century, After Watkins 1994, Fig.23. Group 1, used clinker boat frame timbers, and knee and frame rough-outs; Group 2, one used 2 piece oak stem, and hewn and sawn oak stem rough-outs; Group 3, 'Y' crotch floor or breasthook rough-outs; Group 4, Roughly squared baulks; Group 5, assorted roughed-out crooks; Group 6, roughly squared baulks.



A



B

Fig. 91 Two representations of clinker boatbuilding. A) Ark building, c. 1315, English (after Harvey 1975, Fig.43). Shipwright appears to be hewing a short hood end board to shape, note the great number of scarfed short boards shown in the strakes of the vessel behind. B) Detail, in Dutch painting by the Master of Gouda, c.1565, (after Friel 1995, Fig. 3.3). Appears to show the building of a small vessel out of short cleft boards. Note the multiplicity of shores, and temporary cleats, the 'clencher and holder' on the port side and the 'shipwright' to starboard.

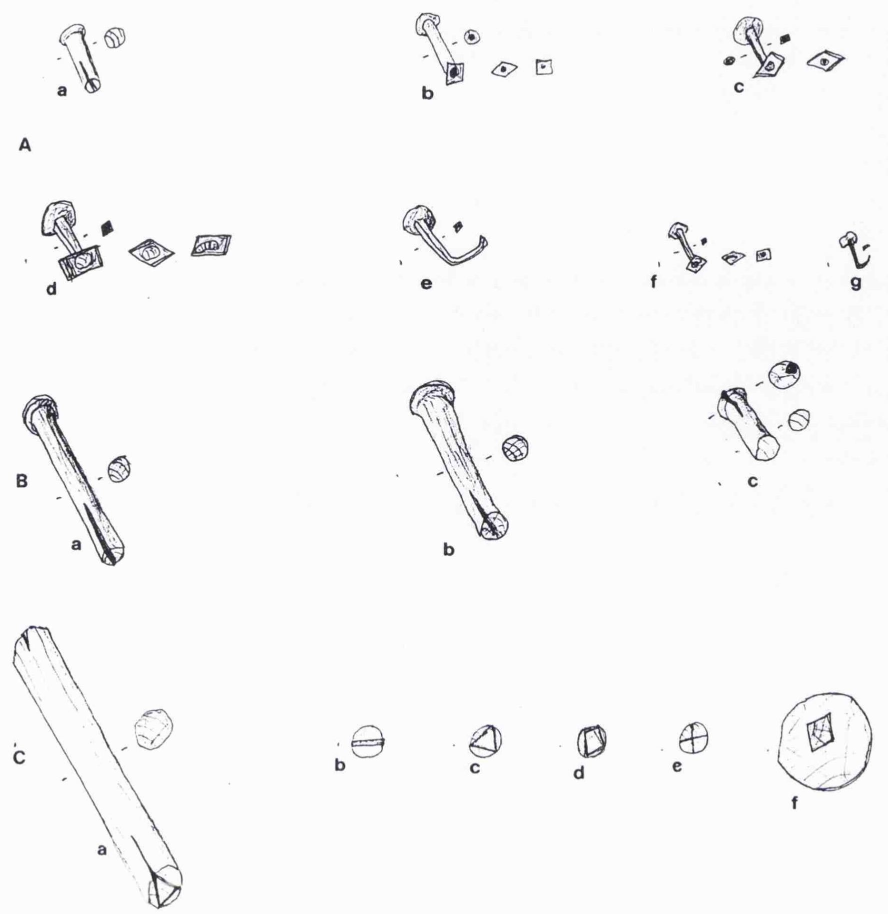


Fig. 92 Sketches of typical clinker lap fastenings, and clinker and carvel treenail frame fastenings, recorded in London boat and ship timber finds c. 900-1600 AD. Refer to Appendix 6 vol. 1 for more information on origin of sample fastenings under the site codes listed.

A) Lap fastenings, also used in scarves, a) Headed New Fresh Wharf type willow treenail, oak wedged inboard, NFW74, TEX88, BUF90, VRY89, UPT90, ONE95, C10th, b) Graveney type, small rawl-plugged, iron rove nail, TEX88, VRY89, BUF90, UPT90, C10th, c) Large iron rove nail more typical of 'Scandinavian Style' (?), VRY89, TEX88, BUF90, C11th, d) Heavy iron rove nail typical of all clinker boards C12th-C15th, but some have more conical heads, e) Hooked iron nails as noted for FW84 keel to garboard laps, f) Small iron rove nail, JAC96, MGS96, TWE98, etc C16th-C17th, g) Repair nail iron, hooked common all periods in clinker work, head shapes vary.

B) Frame fastening treenails c. 900-1400AD, a) Bulbous headed willow, oak wedged inboard, BUF90, TEX88, HOR88, CU72, TYT98 etc. C10th-C14th, b) Bulbous headed oak, from sites as above, but less common, probably for repairs, c) Spiked treenail head, for repairs, also from sites as above.

C) Post-medieval frame treenail fastenings clinker and carvel vessels, a) Facetted, cleft oak treenail, little swelling at head, ABO92, BEY95, VIT96, BOY86, etc, (16th-C19th, b) Oak wedged end BOY86, C17th, c) 3 caulked splits, outboard, BOY86 C17th, d) 4 caulked splits, outboard, as above, e) 2 caulked splits as a cross shape, as above, f) Oak plug outboard (dottel), JAC96, c.1600AD.

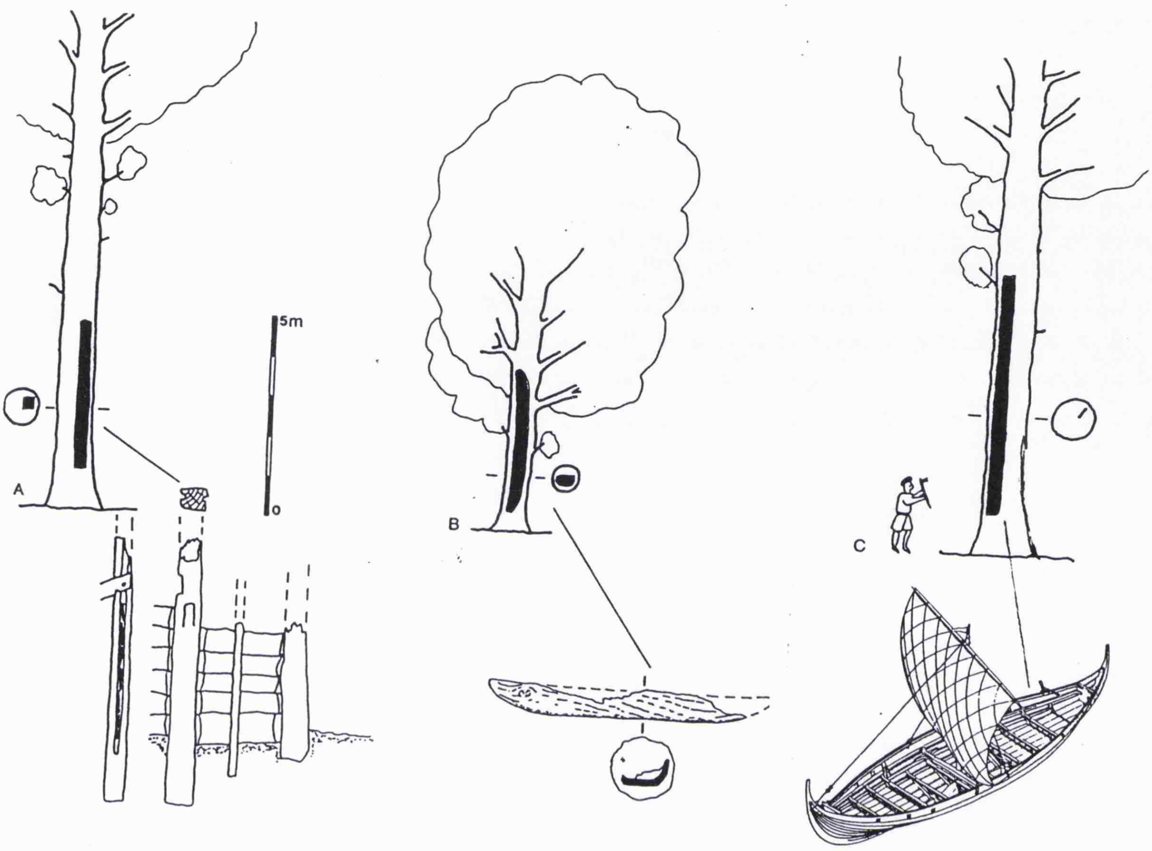


Fig. 93 Hypothetical parent oaks and status; three Saxo-Norman examples. A) A strongly constructed river wall in the bulwark style, of 1184, from TEX88, London, and a large, wildwood, parent oak for the main posts (redrawn from Goodburn 1992,a, Fig.110). B) The 10th century Clapton dugout boat and its moderate quality reconstructed parent oak. C) A typical large straight, wildwood 'board' oak for long Saxo-Norman shipboard, and the Skuldelev 3 vessel which had radially cleft boards up to 6m long, after Olsen and Crumlin-Pedersen 1978.

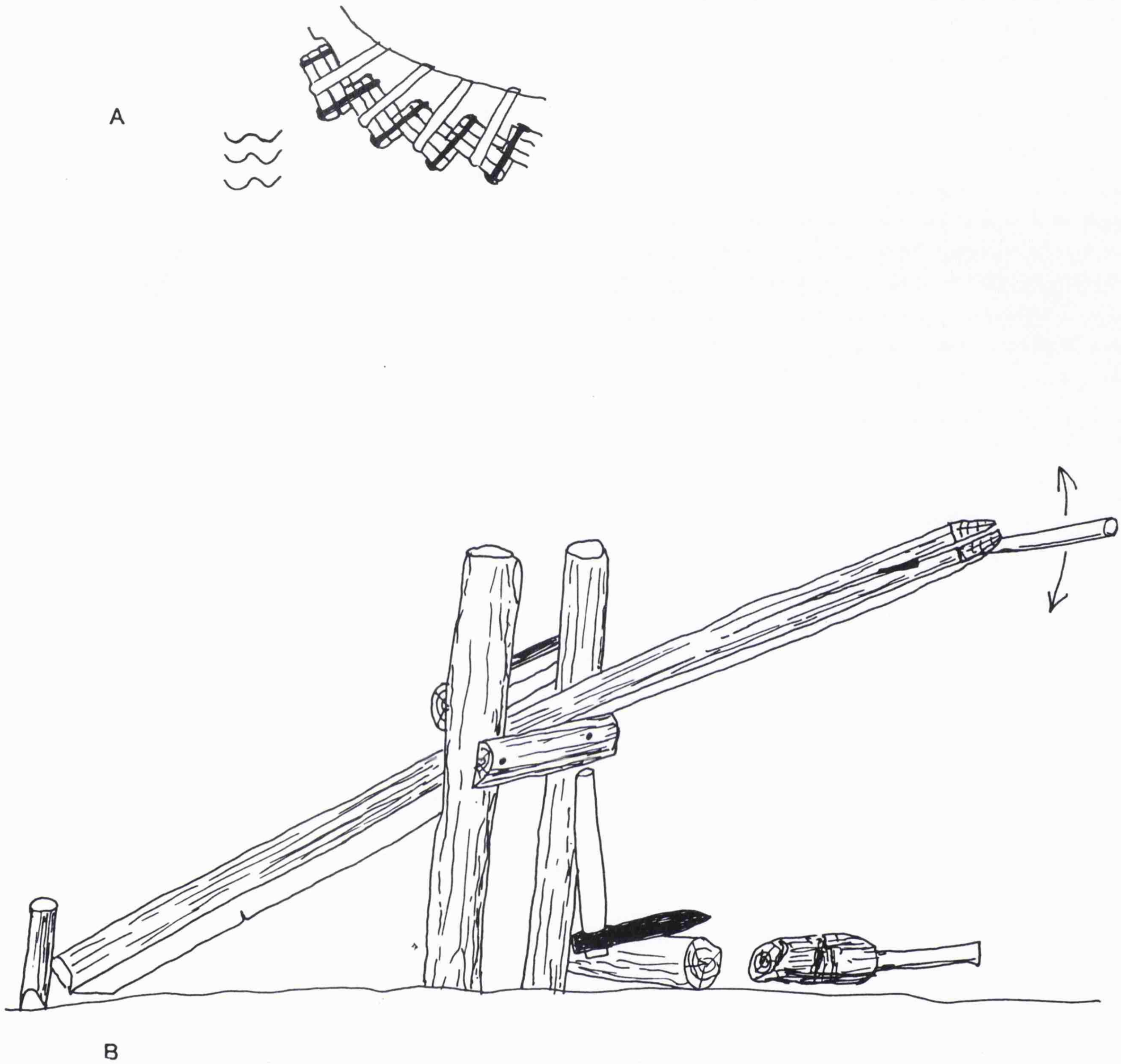


Fig. 94 The use and production of short late medieval and 16th century oak ship board. A) Diagram of the triple thickness clinker hull system used in the Grace Dieu of c.1416, made of boards as little as 6' (1.84m) long (redrawn from Hutchinson 1994, Fig.2.3,d). B) A 1/16th log section of oak c.2m long being cleft using the traditional English 'froe and break' method. Proportions, about those used for the small clinker boards found at JAC96, London, of c.1600AD. Note the froe and froe-club on ground.

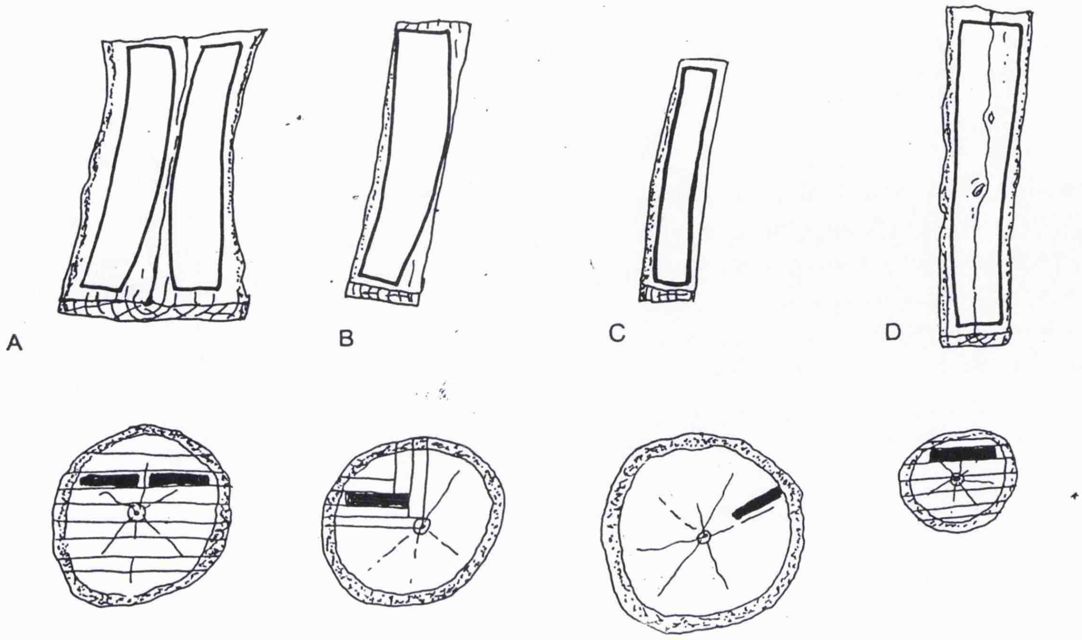


Fig. 95 Diagram showing four sources of clinker boat boards. A) Paired boards, cut from wide a through-sawn slab, avoiding the weak pith, as in recent English practice. B) Board cut from a 1/4 sawn plank, a possible but unlikely 16th-17th century practice. C) Board cut from small cleft board of typical late 16th century proportions. D) Board cut from small to medium sized pit-sawn oak or elm plank, as found in some 16th to early 17th century contexts in London.

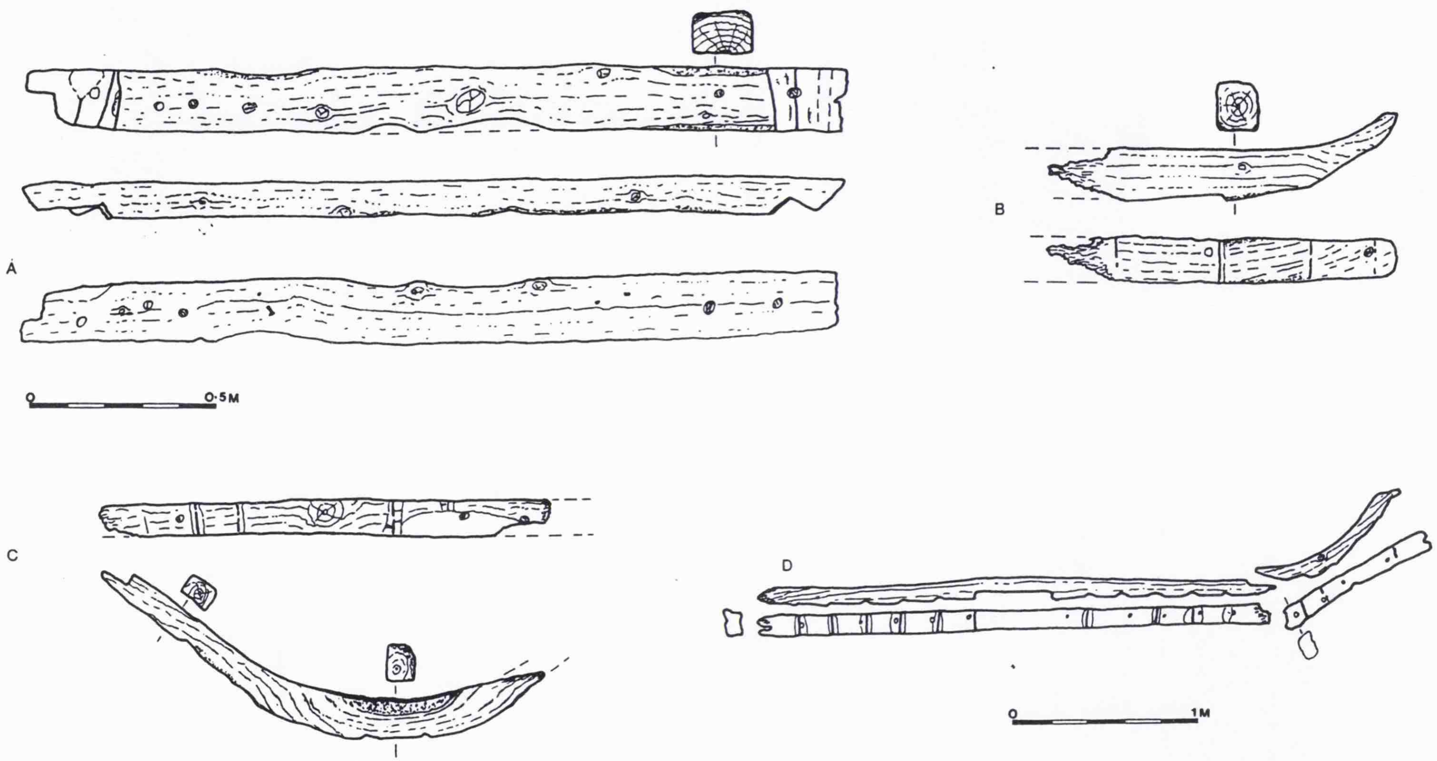


Fig. 96 Some Saxo-Norman and medieval oak framing timbers from the London area. A) A boxed halved oak ship beam, [S.440] HOR86, Kingston, of c.1300. B) A 10th century floor timber fragment, [7271] UPT90, London. C) A floor timber from the ends of a fairly small c.12th century vessel, [12288] VAL88, London. D) A typical midships floor ('wrong') and futtock ('fottock') from the Blackfriars 3 barge of c.1400 (redrawn from Marsden 1996, Fig.58).

Fig. 97 A two bay cruck framed building ('Clisset barn') during assembly in 1997. The vast majority of the work was carried out using 14th century style methods and tools by hand. A) Gable frame, with hewn and see-sawn paired oak cruck blades. B) Front elevation, showing two bays and half loft to right. (Photo author).

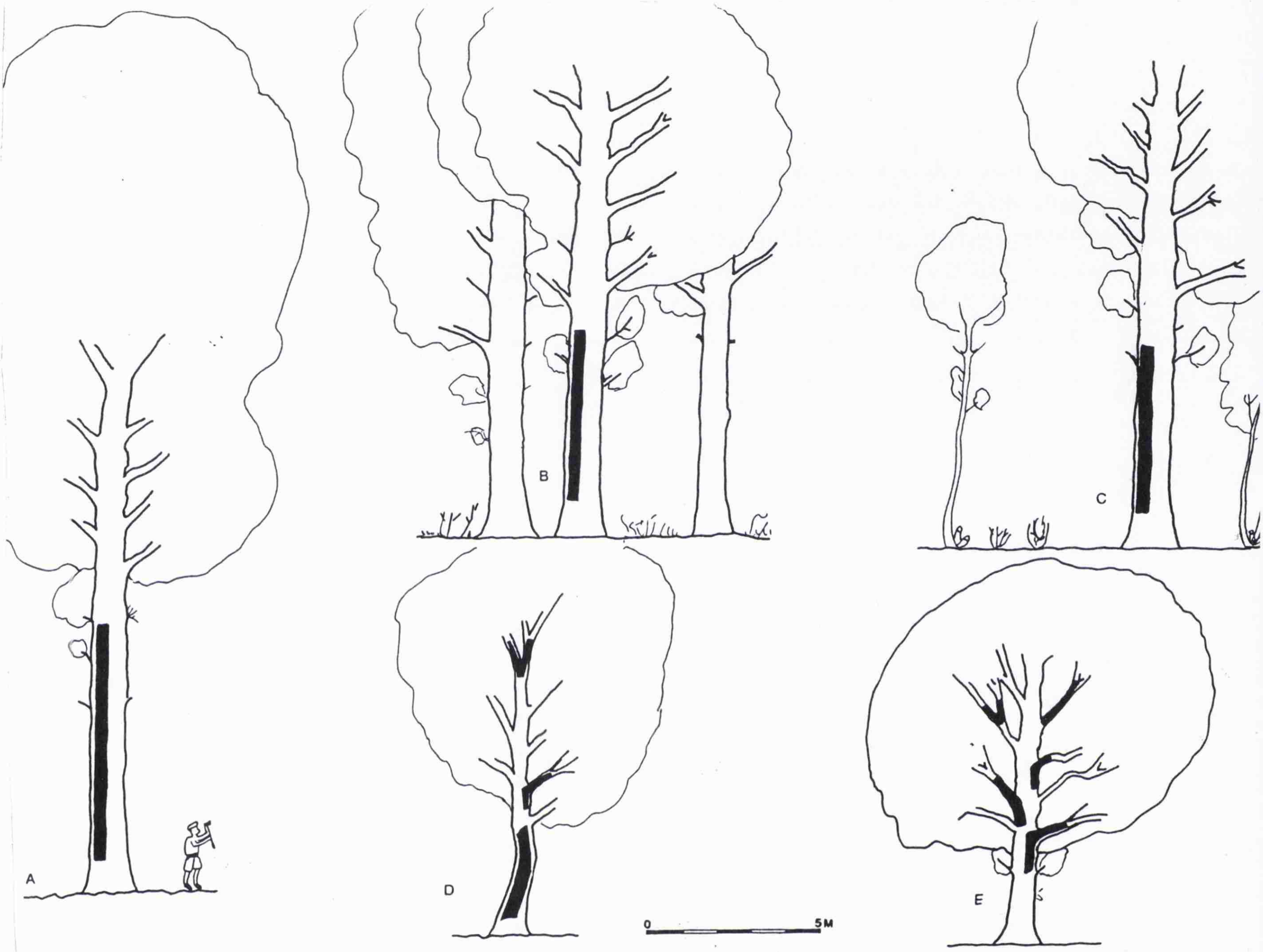


Fig. 98 Some hypothetical parent oaks for English medieval shipbuilding c.1250-1400AD. A) Wildwood slow-grown, oak, 'board tree', in the SE Baltic region, or Ireland. B) A large, straight, fast-grown native oak in a grove of large timber trees, cut for cleft ship board. C) A particularly straight, 'oversized', woodland standard oak suitable for board making. D) A crooked woodland oak for curved stem logs and some small compass timber in the largest branches. E) An open grown (hedgerow or pasture?) oak with heavy branches suitable for large and small compass timber.

Fig. 99 The division of large oaks into several lengths in post-medieval times. A) A large oak from a French managed 'high forest' (Troncais and elsewhere) and its typical tripartite sub-division. The butt log for cleft cask staves, the 2nd log for sawn oak plank and the 3rd, for a sawn boxed heart beam. B) A hypothetical large, straight, English parkland or woodpasture oak of the 16th-17th centuries, and its possible sub-division into a butt log for the small cleft ship board of the period, and a longer 2nd length for wide sawn plank or a large hewn or sawn beam. Heavy boughs may also have provided framing timbers (crooks, and bends).

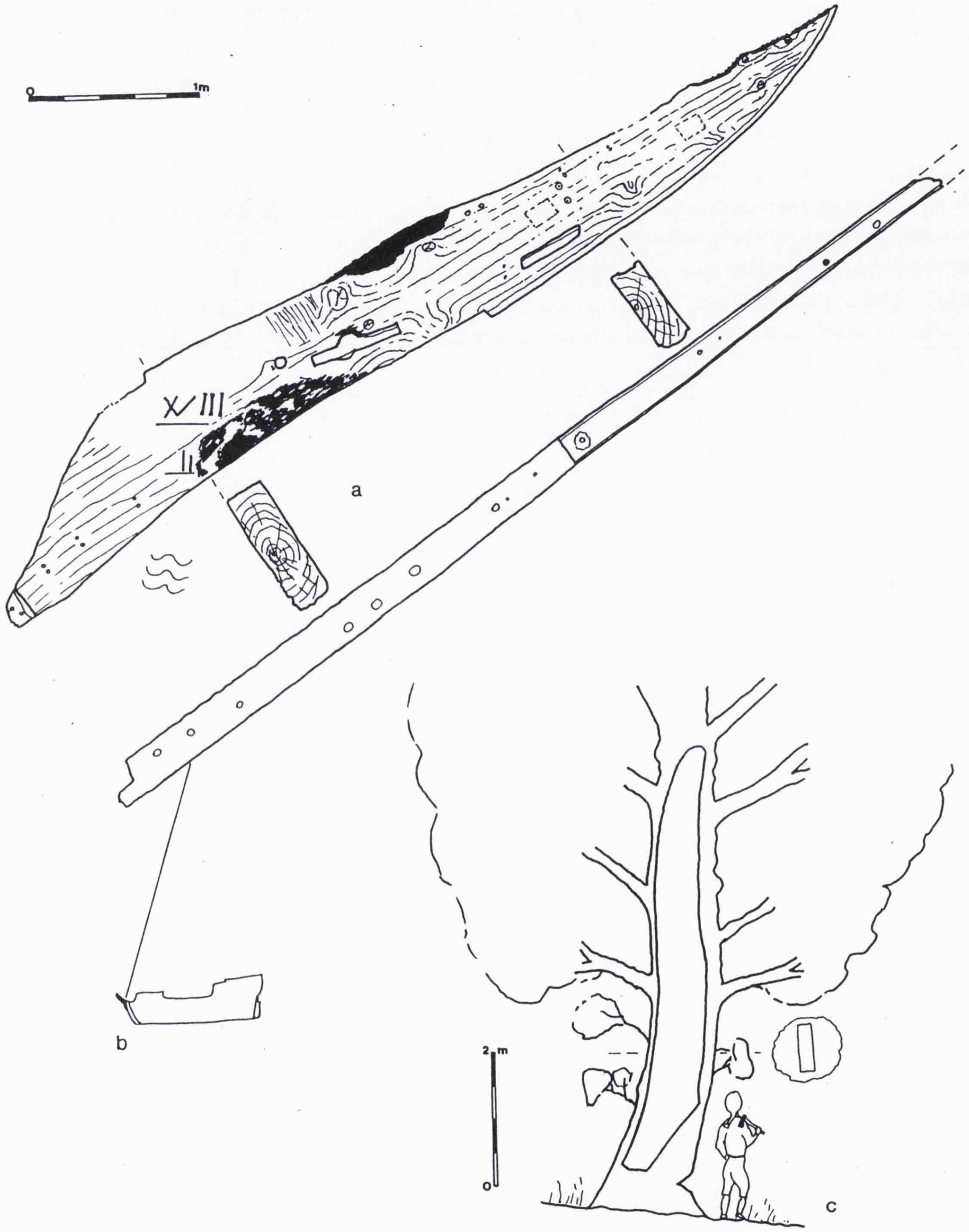


Fig. 100 A 17th century reused ship timber and its origin, in ship and tree. A) The almost complete, charred, beak timber from the bow of a large early to mid 17th century ship, from BEY95, London. B) Its point of origin in the parent vessel. C) The hypothetical fast grown parent oak reconstructed. It may have grown in a hedge or similar setting.

APPENDIX –1 GLOSSARY

Notes- The following list of specialised terms and brief explanations are based on the writers own experience of common usage amongst traditional English wooden boatbuilders and woodsmen over the last 25 years. Some terms derive from archaeological usage, and readers might find it useful to consult other nautical archaeology glossaries such as that in Ancient boats in NW Europe, or Medieval Ships and Shipping (McGrail 1987:xix, Hutchinson 1994a:183-190). Some terms coined by O. Rackham have been adopted here derived from his 1976 review work (Rackham 1976, also see index to Rackham 1980). No apology is made for the use of obscure but historic craft dialect terms (see, Chapt.3 part 2). The use of recently invented archaeological jargon has been avoided wherever possible as it is often ambiguous, or misleading such as the term Dendrochronology, that is, of trees and time. The term tree-ring dating, or, where relevant, tree-ring study (tree-ring analysis) is used instead as such work is used for several other purposes in addition to dating (Append.7).

ADZE- Edge tool used with chopping action, for shaping and smoothing timber etc. blade set cross wise to that of an axe.
AS CLEFT- A surface left torn and rough from cleaving.
AUGER- Tools for boring holes in timber, usually larger holes.
BERDER- Also 'border', in medieval English shipbuilding context appears to mean 2nd status of shipwright after master shipwright. Probably craftsman responsible for trimming boards prior to cutting edges to shape?
BILGE- Lower part of a hull inside.
BILLET- Short split section of log.
BITR- Old Norse term use for combined knee and cross beam typical of medieval Scandinavian building systems.
BLIND NAIL- Nail that does not pass right through a timber. Also 'dead nail'.
BOARD- Usually fairly thin plank, often made by cleaving, rather than sawing.
BOARD TREE- Large straight grained tree over about 0.7m dia. at chest height often 1m+ dia., common in lowland wildwood, which can be cleft into boards. = 'veneer butt' of modern timber trade.
BOAT LEVEL- Tool with plum bob attached for finding angle to vertical of a board or plank in clinker work. Various forms.
BOTE- A feudal customary right to materials for household use, for peasants and tenants.
BROAD AXE- Wide bladed axe for hewing and trimming timber, not felling or bucking.
BUCKING- Cross-cutting log or felled tree stem.
BURTHEN- Loaded capacity, also burthen boards-loosly fitted lining of inside of lower hull. Also 'burden'.
BUTT LOG- Lowest log cut out of a tree, usually the most knot free.
CALFATAGE- French term for caulking or similar used in some late medieval English documents.
CARVEL- System of vessel construction where hull planking is not joined edge to edge but to internal framing. May be shell first or plank-on-frame, skeleton first.
CAULKING- Verb and noun. To drive fiberous material into seams to waterproof after fastening. Mainly associated with carvel building, and waterproofing seams and laps in cog and hulk construction. Not to be confused with luting. Often this term is miss applied causing much confusion in nautical archaeological literature. Caulkers-workers who specialised in it.
CHATTER MARKS- Small ridges, usually across the grain made during scraping, shaving or planing.
CHINE- Sharp angle in the cross section of a vessels hull, commonly between the bottom and sides of box-like craft.
CLAPBOARD- Boards laid to slightly overlap in a building wall, of triangular cross section, originally radially cleft. Also 'clapholt' of some medieval documents.

CLEAVING- Controlled splitting of timber or wood, also known as 'riving', or 'rending', in England.
CLENCH- To deform nail tip over rove.
CLENCHER- Person who clenched nail tips in clinker work and probably other work, apparently senior to a 'holder'.
CLOVYER- Woodworker specialising in cleaving. Also clovier.
CLINKER- System of vessel construction, where hull is built of shell of centerline timbers and slightly overlapping planking, edge fastened at the lap, framing inserted later.
COMPASS TIMBER- Naturally curved logs, to be cut into ship framing elements.
COPPICE- Ancient and continuing system of woodland management where trees are cut down close to ground level when young and grow back fast with multiple stems from same root system. Often cut after as little as 3 years growth in medieval England. Material mainly used for fuel, fencing and woven panels in buildings. Woven panels, 'hurdles' sometimes used for temporary hold linings in medieval vessels. Coppice products usually 'wood' rather than timber.
COPPICE WITH STANDARDS- Intensively managed woodland were the above is combined with larger 'timber' trees. V. common in SE English ancient woodland and all over England in medieval period.
CONVERSION- The process of changing a log or sometimes a baulk into beams, boards or planks. Subdivided into 'Method of Conversion' ie. how it was done, and 'Type of Conversion' ie. the section of a log used.
CROOK- Piece of timber grown naturally to a curved or hooked shape,
GARBOARDS- Boards or planks set next to the keel of a vessel. Also 'sandstrake' or 'sandstroke'.
DOLLY- Heavy piece of iron used to support fastening or timber during driving of fastenings.
DOUBLE-TRESTLE SAWING- Sawing timber lengthwise on two trestles cutting from both ends.
DROP- First, wedge shaped cut made in base of tree to direct fall. Also 'Gob', 'Sink' and 'Birdsmouth'.
DUGOUT BOAT- Boat formed of hollowed log or half log, perfered to 'logboat' or 'dugout canoe' as neither term is clear.
DUTCHMAN- Inset patch on timber, usually plank surface. Also 'graving piece'.
END SHAKES- Splitting of end grain on drying of timber.
EXTENDED DUGOUT- As above with planks or planking added to sides and or ends.
EXPANDED DUGOUT- Dugout boat or lower hull made wider by distortion after hewing.
FACET- The whole surface created by one cut of an edge tool, often flat,
FAYE- To smoothly fit against another timber.
FLARE - Lean outward of a hull in cross section.
FLOOR - Lowest element in cross wise framing ofa vessel
FOREST- Place were certain laws applied and royalty had many rights to game and timber, principally concerning deer rather than timber. Some forests had no trees, not to be confused with woods or wildwood and other forms of 'treeland'.
FREEBOARD- The height of the lowest point of a vessels side above water.
FROE- Tool for cleaving comprising thick knife like blade with eye for handle to twist blade to extend split. (fig.94).
FROE CLUB- Coarse mallet in one piece for driving froe into end grain of wood or timber. Has many other regional names eg. 'dullaxe', 'dill axe' etc.
FUTTOCK- Upper element of vessel framing. Also 'footick'.
GROWN- Natural shape of a piece of timber.
GREEN- Freshly cut timber or wood, with sap in, soft easy to work.
HANG- Verb and adjective. To fasten a plank or board into possition. Also the shallow sagging line of hull strakes in the upper part of most vessels, opposite to 'sny'.
HEWING- The shaping of logs or large sections of timber with axes and or adzes (with adzes sometimes known as 'dubbing').

HOLDER- Person who holds a dolly against the nail head when fastening a rove nail, the most junior form of shipwright. Also 'holyer' in medieval English documents.
HOOD ENDS- Planks or boards from the ends of a vessel adjoining a stem, possibly derived from 'hewed-ends'?
HIGH FOREST- Area of high dense woodland managed by selective felling, for timber.
HULC- Medival term for vessel with dugout lower hull, in early medieval times, later usage ambiguous for forms of large ship.
HULK- Vessel partly dismantled for secondary use and or deliberately dismantled. Not to be confused with a wreck.
INCUTS- Cuts down through the surface of a timber, often left behind in hewing a timber surface.
KEEL- Two meanings: Firstly, a type or form of vessel, clinker built, with rounded hull, and pointed at both ends. Secondly, the main lowest centre line element of beam or plank-like cross section of a vessel. Also 'ceol' in early documents.
KEELSON- Longitudinal timber usually placed on top of floors. Also 'kelson'.
KNEE- Bracket of timber,
LAP- The overlap of the edges of clinker boards or planks, also 'land' or 'hem'.
LOG- Section of cross cut or bucked tree stem.
LOP- Verb and noun, (to cut) side branches of a tree or log.
LOT- Scandinavian term for centre line timber linking keel to stem. Medieval English term probably 'under lout'.
LUTING- Noun and verb, Laying of a mastic and or fibre between two timber surfaces before fastening so as to waterproof join, most commonly in clinker laps and scarfs. Not to be confused with 'caulking'. Also 'scion' the Northern Isles term.
MASTER SHIPWRIGHT- Most senior grade of trained shipwright.
MAUL- Large wooden mallet usually made in one piece.
MEDULLARY RAYS- Vertically aligned cells in timber or wood, planes of weakness followed for cleaving, clearly visible in some species such as oaks or beech.
MOULDED- Dimension cut to a mould or pattern, or simply the dimension cut to a curve in nautical woodwork often varies along timber, more specific than thickness.
NIPPERS- Clinker boat builders wooden claps.
OAK- Here used to refer to Quercus robur L., or Quercus petrea L. (penduculate oak, or sessile oak) or hybrids there of, the 2 oaks native to England and NW Europe. The first named has stems on the acorns and not the leaves, the second has stemless acorns and stems on the leaves. Archaeobotanists in England state that the two species can not be distinguished microscopically, they can not by eye. However, as trees they are still differentially selected by some English woodland craftsmen, and in some parts of N. Europe they still have seperate common names eg. Danish 'stilkeg' (Q. robur L.) vintereg (Q. petrea L.).
OFFER UP- Process of holding a board, plank of timber in place for assessing quality of fit to other timbers.
ORLOKE- Medieval English term for hole in a vessels hull through which an oar could be used. Also 'orruck' or 'oar-port'.
PALE- Cleft board, usually rather narrow and less than about 2.5m long, used vertically in a fence or pallisade. Some times a halved log.
PARENT LOG- Hypothetical log from which a timber was taken or cut.
PARENT TREE- Hypothetical standing tree from which parent logs were bucked.
PARENT TREESCAPE- Treescape from which a reconstructed parent tree was harvested.
PAYING- Act of spreading a mastic material along a seam.
PIT-SAWING- Act of sawing timber or log lengthwise from one end to the other over pit, or on above ground gantry.
PITH- Central channel in a tree from which medullary rays radiate, weak point and focus for shakes.
PLANK- Piece of worked timber much wider than thick, usually thicker than board. In medieval England seems to imply sawn material. Also verb- act of adding planking to a hull.
PLUG- Small piece of timber driven into tight hole, or end of treenail.

POLLARDING- Cutting trees at heights from c. 1.5m, so resultant shoots above browsing height of local herbivores. Stems sometimes used for timber as well.
QUARTER SAWN- Method of sawing timber lengthwise from a quarter log so as to achieve radially faced material.
RABETT- Boatbuilders term for rebates especially along the centre line structures where planking of hull joins.
RADIALLY FACED- Board, or plank cut so annual rings are at more than about 60 degrees to the face, in cleft material medullary rays will by near parallel to the face.
RADIALLY CLEFT- Timber or board split out of a log following medullary rays.
RAKE - Top of stem or ster slopes outward.
RIB- Cross wise frame timber, usually in smaller vessels, sometimes in 1 piece.
RISERS- Longitudinal timber usually under thwarts.
ROCKER- Curving up of the ends of a vessels bottom.
ROUGH-OUT- Act of prelimenary shaping of a timber.
ROVE- Washer-like plate of iron, usually 4 sided, through which nail tip to be rivetted or 'clenched' passes.
ROVENAIL- Rivet-like nail and rove widely used in clinker boat and ship building.
ROVE SET- Tool with hole in one end to drive rove over nail tip.
SCRIBING- Scratching a lin or mark on timber surfaces, to aid cutting out or labelling in some way. Specialised tool for so doing sometimes called a 'scribe'.
SEE-SAWING- Act of cutting timber lengthwise with a saw from both ends to a fulcrum near the mid-length, resting on a single trestle as in the childrens play ground equipment.
SPAR- Rounded long timber used to support rigging and or sails.
SPILING- Process of finding the shape of a timber, board knee or plank to be to other timber in a hull. Carried out in many ways.
SAW KERF- Cut made by saw.
SAW KERF-JOIN SCAR- Irregularity on face of sawn timber where 2 saw kerfs meet, usually slightly missaligned.
SCANTLINGS- Cross sectional dimensions of timber.
SCARF- End to end joint of some form. Also 'sker'.
SCHEBEME- Medieval English term for cross beam in vessel
SCORE- Groove cut to enable waste timber to be split off during hewing.
SEALING- Lining of the inside of a vessel, modern coruption 'cealing'.
SEAM- Longitudinal joint between planks, in carvel and cog building.
SEASON- The drying out of the watery sap of freshly cut green timber, with achievement of hard sufaces and no further shrinkage.
SETWORK- Tar and hair laid between timbers or planks usually over large areas. Similar to luting in meaning. Also 'hair n, blair'.
SHAKES- Drying cracks.
SHEER-Line of the top edge of a hull side. Usually a shallow curve.
SHOWT- Medieval English term form forms of river and estuary barge. Also 'shoute'.
SHREDDING- Cutting off side branches repeatedly for fuel.
SHRINKAGE FACTOR- McGrails term for a measured degree of shrinkage in waterlogged timber.
SIDE AXE- Specialised axe with blade bevelled on one side only, for trimming and smoothing timber and secondary stages in hewing.
SIDING- Dimension in for and aft for frame timbers, similar to thickness. Also a verb.
SIGNATURE- Pattern of ridges and grooves on a tool mark facet, distinctive to the nicks in the blade of a particular tool.
SINTEL- Low countries boatbuilding term, for staple-like iron fastening used to hold batten down over caulking in a seam. No English equivalent term known. Used in cog and hulk building.
SKID ROAD- Track of cross-wise set logs to drag heavy material such as large logs, over.
SNY- The downward curve of a strake, mainly found in the lower parts of a vessels hull.
STEALER- Narrow short plank or board inserted for part of the length of a strake.

STEM- Centre line structural member set near vertical at the forward or sometimes after end of a vessel. Landsmen use 'prow' as equivalent. Can be more than one timber.
STOPMARK- Line left by end of travel of edge tool on timber, a negative of the blade edge profile.
STOPPING- Verb and noun. Material set in seam, lap or hole near surface of timber to make watertight. Usually set over caulking in a seam.
STRAKE- Line or course of planking, or boards in a hull, comprised of several boards or planks, rarely one piece. Also 'stroke'.
STANDARD- A medium sized to large tree allowed to grown on for timber over c. 0.15m dia. minimum. Also 'staddle'.
TENDER- Unstable.
THWART- Plank-like timber running from one side of a vessel to the other,
TANGENTIALLY FACED- Timber or plank cut so that annual rings meet the face at about 60 degrees or less. Usually most of the width of the tree.
TIMBER- In a medieval context, sections of larger trees (+ c.0.15m dia.) usually oak but could be other species such as Beech. 'Merimium' in some medieval texts, includes beams, planks and boards. Not to be misstaken for 'wood'.
TINGLE- A patch fastened to inboard or outboard face of hull plank or board. Most commonly in clinker work.
TOP LOG- Log cut from upper part of a tree stem.
TOP- The uppermost parts of a tree. Also 'crown'.
TRANSOM- Cross wise assembly of planks and framing in larger craft to make square end to a vessel.
TREELAND- Term coined by Rackham as umbrella term for all land with trees on including hedges, woodpasture, wildwood, orchards, woods, plantations, etc.
TREENAIL- Tight fitting cylindrical wooden peg fastening, usually goes though 2 section of timber or board some with one end left bulbous and the other wedged to hold like rivet. Others have both ends split and expanded (fig.92). Also 'trenail', or 'trunnel', or 'clavorum ligniourm'.
TREESCAPE- Trees in a living setting.
WALE- Thick longitudinal timber inboard or outboard.
UNDERWOOD- Principally coppiced trees growing below standards.
WAYS- Timber structure set under vessel for launching.
WILDWOOD- Area of tree cover very little effected by people, in most of England this would have grown tall and dense including many large straight trees 1m and over in dia. with slow growth girth wise. Also would have contained many fallen trees and some 'gaps' created by natural agencies such as windthrow, flooding, disease and large animals. Varied through time and with soil and aspect etc. Produces good, board trees.
WILDWOOD-TYPE WOODLAND- Area of tree cover with little human management where trees grow to size and form of virgin wildwoods, may have developed on managed woodland sites, or even open ground after collapse of Roman land-use patterns in SE England.
WOOD- In a medieval context, generally small woody material from trees, coppiced or pollarded stems, and branches and tops of larger trees. May also have been larger logs of species rarely used as timber eg Birch. Termed 'Bocus' in some medieval accounts not to be confused with 'timber'.
WOODLAND- In a medieval context; a defined, often fenced or embanked block of trees, used for wood and some timber in most cases.
WOOD PASTURE- Land-use combining scattered trees with grazing. Trees often pollarded. An artificial form of savanna.
WOODMANSHIP- Apt term coined by O. Rackham to describe ancient systems of managing trees, shaping them and felling or prunning them mainly for repeated fuel or pole crops, (coppicing, pollarding, and shredding) but also for timber in the longer term. Goes back at least to the Neolithic in Britain.
WRONGS- Medieval English term for ship or boat lower frames (floors), also apparently for logs suitable to make them. Also 'Wrung', 'rung', and 'wrang'.

APPENDIX - 2

RECONSTRUCTING "TREE LAND" FROM AN ANALYSIS OF NAUTICAL TIMBERS OF PRE-CONQUEST AND MEDIEVAL DATE.

SOME DEFINITIONS

"Timber"- Woody material from medium sized and large trees, principally cut from their stems or largest branches (for curved nautical knees, or frame timbers). In medieval England "timber" as opposed to "wood" was treated differently in law as far as its use and ownership was concerned. A lord might own the timber sized trees growing on a patch of land, whilst tenants might have free access to the smaller wood, mainly for fuel (See Rackham 1976:83, 1980, for more on the historical and social importance of these points).

"Wood"- Small diameter poles and branchwood, used principally for fuel (as in the modern English "firewood" rather than "fire timber") and for light construction. In practice the border line between wood and timber must have varied a little with time and place, though it a lay between about 15 and 20cm diameter in high medieval England. Small structural timbers for buildings were often cut from quite young oaks only 15 cm in maximum diameter. In modern England,by contrast, an oak of 40cm diameter would not be considered worth treating as timber by most sawmills or timber merchants.

"Tree land"- This phrase, coined by Rackham, is needed as it is clear that for thousands of years in England trees have grown in very varied types of environment, these include coppice, coppice with standards, wildwood, high forest, woodpasture, hedges and orchards. All of these except wildwood are cultural landscapes which could not exist without the active management of people through, felling, pruning, controlling grazing and fencing (See Rackham 1980).

"Coppice"- A system of woodland management which involves the regular cutting down of areas of woodland in cycles of a few years to produce large quantities of small regular poles . Though some of the products of coppices were clearly used for light construction work such as fencing, wattle buildings , coracles, currachs, fish weirs or building elements the majority of the material was used for fuel. In high medieval England, if not earlier, this was "energy forestry" for domestic and all industrial processes (often processed as charcoalfor irom making and working etc) until coal became available. This system of management is still practiced in parts of S.E. England

"Coppice with standards"- As above but with varying proportions of larger trees allowed to grow to timber size . In many areas of high medieval England this system appears to have been the most common type of treeland. Commonly standards only produced straight moderately knot free timber in relatively short lengths of about 2.5 to 4m this was because the coppice surrounding the standard trees was normally cut down at a height which allowed the standards to get a constant supply of light at between about 2.5 and 4m and thus maintain large branches at that level. Additionally the repeated cutting down of the surrounding coppice or "underwood" allowed light in to ground level every few years thus small side branches could be repeated sent out from the main trunk below the first main branches. This is called "eppicormic growth" and can produce a series of small knots in timber cut from such trees. This system of management is still practiced in S.E. England

"Wildwood"- ("Wildwood type woodland") Natural tree covered land containing many very large old tall trees such as oaks which could be used to produce long knot free planks or timbers. By Norman times it is generally thought that there was relatively little wildwood surviving in England most of it having been converted to other types of managed woodland , or wood pasture and eventually pasture and arable open land (Rackham 1976:39, 1980, and Goodburn 1991b, 1992a, 1994b etc.). However, it is also considered that there were pockets surviving till perhaps the mid 13th century in places like the Forest of Dean and the Weald just to the south of the London area. The subject of the nature of temperate wildwood has recently become a focus of historical ecological research amongst practical botanists and ecologists. Rules of thumb for the recognition of typical wildwood trees in northern hemisphere temperate zones have been developed (Peterken 1996:149). This proposes, on the basis of considerable international research, that woodland of this type in the temperate zones is likely to contain many tall, mature trees around 1m in diameter and c. 200 years old. Interestingly this basic generalisation was being developed a few years earlier by this writer from during archaeological work with hundreds of ancient timbers of varied character and varied date being excavated in London's wet zones in 1990 (Goodburn 1992a:118 etc). After examining and recording several thousand waterlogged timbers (mainly oak) from buildings, wharves, bridges, well linings, boats, ships fencing and barrels and reviewing many tree-ring reports it is clear that the early suspicions were broadly correct.

Wildwood type woodland - is a theoretical type of treeland which has the key characteristics of more or less virgin wildwood but it might include some areas that had centuries before been managed woodland, or after longer still more open areas of prehistoric managed landscapes. Ecologically the wildwood type woodlands growing up on 'tamed woodland ' sites may not be exactly the same as entirely virgin areas but in terms of the bulk of the tree cover it is likely that they would have looked very similar after very low intensity interference for 200 years or so.

Now we might suggest that a typical early medieval "wildwood" type oak, beech or ash would have been tall and straight c. 200 to 300 years old and c. 0.85 to 1. 2m in diameter at chest height. when its life was ended by being felled for structural use particularly making boards. Clearly areas of wildwood would also have contained both younger and older trees and many of less useful species which are under represented in the archaeological record. Clearly the selection procedures and requirements of various woodworkers has produced large skews in the evidence for wildwood or wildwood type woodland and the results of other studies of roundwood, charcoal, and localised targetted pollen analysis must be considered to get a fuller view of all the trees of the wildwood (s).

"High forest"- This system of management involves the selective thinning of unsuitable trees to produce tall regular timber trees, which are felled in small numbers when they reach optimum size. Though similar in some ways to modern forestry or plantation management, which only developed in the last 250 years in England it, does not involve clear felling large areas but operates on a selective principal. This method of management is still practiced in the Chiltern beech woods but is otherwise very rare in England though well known in northern and central mainland Europe. One of the results of this study is to suggest that small areas of this type of woodland may have been more common than previously thought and were reserved for special purposes (see section..... of the main text).

"Woodpasture"- Sometimes loosely referred to as parkland, this system of management involves the practice of letting trees grow in individually or in clumps surrounded by grassland . These trees can be single stem individuals or often pollarded trees. This type of management can still be seen in ancient parkland in SE England, such as at Windsor Great park, or Hatfield Forest.

"Pollards"- These were and are trees that are repeatedly cut off at between about 1.1 and 3m (sometimes higher) this is to protect the regrowth of poles from grazing by wild or domestic animals. The products of these trees were heavily used entirely for fuel, or charcoal production as the poles produced are less regular and more knotty that those produced in coppices. Pollards can still be seen in the London area at places like Epping Forest. However, it is also clear that they could be used for timber if they were cut tall enough and short boards and planking made from them (Goodburn 1994b, and 1998).

"Forest"- This term is avoided in this study because it is so often misunderstood. Where it is used it is in the medieval English sense of an area of land managed under the royal forest laws. Medieval forests in the S.E. of England usually did contain large numbers of trees and supplied timber such as Windsor Great forest but other forests had few if any trees.

"Hedges"- Now we are familiar with neatly trimmed hedges in suburban or rural areas and it is often difficult to see them as sources of wood and timber. However Rackham has shown that they could be a major supplier where they were allowed to grow thick and tall. Spreading timber trees growing in hedges or wood pasture environments produced large curved boughs which could be used for making curved ship frame timbers . Coppice with standards or high forest timber trees rarely produce heavy enough main branches for large vessel frames though they would suffice for small boats. The usefulness of these open grown oaks for curved ships timber is demonstrated in records of the 1608-9 survey of timber growing on crown lands carried out for naval building purposes, where trees were classified according to how many "riders" "futtocks" or "knees" (all particular types of curved ships timber) they could make (Rackham 1986,217). Elms in particular are typical trees of Thames and Medway flood plain woodlands to day, but are now only visible as large decayed stumps or small trees because of the current wave of Dutch elm disease. Once they were a major source of structural timber for foundations, carpentry, and ship and boat building.

"Orchards"- There is no evidence of the ancient use of fruitwood in English boat building so for the purposes of this study we can ignore orchards.

FIRST ATTEMPTS AT THE RECONSTRUCTION OF PARENT TREES AND WOODLANDS.

The first researcher to recognise the full potential of early timber structures for reconstructing the types of trees used by early woodworkers was Oliver Rackham (see Rackham 1972 for example). He has analysed medieval timber framed buildings and reconstructed the types of trees used to build them, or at least their frames. He also recognised the potentially valuable contribution of archaeological excavation of waterlogged sites for the reconstruction of ancient woodlands (Rackham 1976,51). Unfortunately this potential has not yet generally been realised by the wider archaeological community and relatively few studies have been have been carried out If one could site a lack in this aspect of Rackham's work it would be that he has not examined sheathing and flooring timber (as they rarely survive from the original build) to any great extent which perhaps skews his data base to some extent. That is his source material does not include some of the evidence for the use of larger diameter trees used to make sawn plank or cleft boards.

Occasionally efforts have been made by workers in the nautical field to reconstruct the nature of the trees used to build the finds under study. The first tentative efforts of this type were made by Fox in his 1926 study of dugout boat finds, many of which he realised were pre-Conquest or medieval in date (Fox 1926). However, his approach was not systematic though he clearly new something of the nature of oak trees and how this set limits for dugout vessel construction. Foxs' work was developed in a more systematic way by McGrail in his survey of dugout boats of England and Wales (McGrail 1978). The potential accuracy of these attempts was hampered by the lack of practical data on the building and subsequent distortion of oak dugout vessels, and the lack of general knowledge of ancient tree land at that time.

Practical experience of building Viking period craft using Viking period tools and techniques was bought to bear on reconstructing the parent logs used to build the Skuldulev No3 vessel (Crumlin-Pedersen 1986a). He was able to reconstruct three probable parent logs from which the planking was probably cleft. Important points were also raised about the use of long wide cleft planks as indicators of the prestige of the vessel in which they were used (Crumlin-Pedersen 1997). However, the next step of reconstructing parts of the contemporary treeland resources rather than just parent logs was not taken. This may be due to the relative lack of ancient woodland in modern Denmark, which still survives for comparative study in S.E. England. However we must note that this area is now being addressed with rigour in relation to experiments in medieval clinker shipbuilding at Roskilde. It is also clear that in the late 1990's efforts to reconstruct parent trees for excavated structural woodwork are being taken more seriously in Britain as shown by work such as the Magor Pill ship investigations (Nayling et al 1998).

Other sources for treeland history a part from nautical timbers

For a total view of the treeland existing in any one area during any one period it is clear that a number of different sources must be tapped; charcoal remains, any surviving documentary sources, evidence from historical ecology, localised closely datable pollen deposits, surviving timber and wood, and residues of industrial processes such as smelting or tanning. This study is principally concerned with the reconstruction of timber trees, although the use of wood for nautical fastenings or their manufacture is also examined briefly . Thus, the study attempts to contribute to one main area of reconstructing ancient tree land that has perhaps been ignored in the past but it must be set beside studies using different source materials.

N/B Please note that the terms "primary" and "secondary" woodland are not used in this study as it is quite unclear to this writer what their logical basis as useful terms is as the palaeoenvironmental record of woodland (or treeland) in Britain is one of continual change and local variation from the very earliest re-colonisations after the coldest phase of the last ice age. Many woodland ecologists now see these concepts as redundant.

RECONSTRUCTING TREE LAND A METHODICAL APPROACH.

The logical stages which must be worked through for anybody setting out to reconstruct the "tree land" resources that were being used by early woodworkers have been set out in "Waterlogged wood and timber as archives of ancient landscapes" (Goodburn 1991b). The notes below are expansions of the points raised there and include some new features. Essentially the method has grown out of practical experience of producing worked timbers of the types used in medieval vessels found in London, using appropriate tools and techniques. Even more importantly this work has mainly been carried out in ancient woodland in the London area.

The stages of study and analysis required to effectively carry out this work are listed below.

1. Gaining a working knowledge of the growth habits of certain species in particular environments.

2. Gaining a thorough practical experience of early methods of timber conversion, radial cleaving, tangential cleaving, hewing etc.

3. Producing field records of ancient timbers where the natural features of the timber used are recorded ie the presence of knots, sapwood or wane, the grain patterns, and approximate age etc.

4. Producing field records where the TYPE OF CONVERSION is recorded, that is the section of log used.

5. Producing field records where the METHOD OF CONVERSION is recorded if possible. That is weather the plank was cleft and hewn or sawn etc. Sometimes the decay and erosion which

waterlogged ancient timbers suffer can make this difficult, but usually small un-erroded areas can be found and saw marks or "as cleft" surfaces distinguished.

6. Producing field records which distinguish between the original and secondarily broken ends of timbers, which is very important for the first stage in the reconstruction of the tree land resources used- the reconstruction of the "parent log".

7. Ideally all field records should be backed up by tree-ring analysis which has the potential to - check field identifications of species, provide felling dates or felling date estimates, and to some extent provenance timbers to different European regions.

Having assembled the data in the form of annotated drawings (and preferably tree-ring study l results) the next stage in the reconstruction of the ancient tree land resources used is the reconstruction of the "parent log".

PARENT LOGS.

The parent log diameters given for oak (*Quercus robur, or petraea* .) include an allowance of about 15cm for the sapwood of medium and large sized trees grown in the S.E. of England (an approximation derived from experience of experimental work in the S.E of England). It should be noted, however, that the above figures are merely working approximations ; individual oak trees vary considerably in the amount of sapwood they lay down. This is said by tree-ring specialists to increase the further west oaks grow in Europe (I.Tyers and N.Bonde Pers. Com.).

The position and orientation of any knots in the timber will often indicate weather the log from which it came was from the lower or upper part of the parent tree.

The wandering pith.

Many modern oak logs and ancient timbers exhibit clearly wandering hearts , which are formed by uneven effects of wind, gravity and changing light availability on the growing tree. This characteristic of English oaks has important implications for attempts to reconstruct the type of timber conversion used (section of log used) in any particular ancient timber. If the pith of the log is off centre then radially cleft planks made from it, for example, will be very much wider from one side of the log than from the other. Therefore any calculations of the parent diameter of logs for sections of timber less than half a log (such as radially cleft medieval clinker boat planking) can only be very rough approximations. In addtion for certain types of timber conversion the results obtained from dendrochronological analysis can not be relied upon. In a nautical context this will apply mainly to structural elements such as keels or frame timbers. But even in the case of common radially cleft planking practical experimentation shows that the grain near the ends of cleft boards such as those used for boat planking will often be turning so as to provide a slightly un-representative cross-sections. This is due to the use of the maximum straight grained length of log possible which may run close to a branch point at one end hence the turn of the grain . The phenomenon was recorded in a number of the planks used in the Graveney boat and in the medieval Kingston finds (Fenwick ed. 1978:229,).

THE PARENT TREE.

Using the grain qualities such as straightness and the presence of knots in the hypothetical parent log together with the length it is possible to reconstruct the parent tree from which the log was cut. The largest single problem with this stage of the work is that the length of the parent log will often be poorly defined in fragmentary finds which form the database for the majority of this study. Narrow annual ring widths and straight even grain are taken here to represent an origin in a tall straight tree.

THE PARENT TREE LANDS AND CULTURAL LANDSCAPES.

As the growth habits of oaks (which are the prime species of concern here) are principally effected by the type of environment in which they grow, we can go some way to reconstructing the landscape around the parent tree. For example trees producing long straight grained timbers have to be surrounded by other tall trees in a "high forest" or "wildwood" type situation where they are forced to compete for light, and supported against wind damage. At the other end of the spectrum heavy curved oak timbers can only derive from open grown oaks that we might now find in hedgerows or woodpasture environments. Many of these types of tree land are cultural landscapes and so in reconstructing the parent trees we can provide a three dimensional reconstruction of parts of ancient landscapes.

It is also the case that genetic factors will have some effect on the type of timber a tree produces but this seems of secondary importance. However,the precise species of oak or weather it was a hybrid of the two main species may be a relevant factor, though unfortunately the timber of the two species is not apparently distinguishable in archaeological samples (Tyers pers com.)

EPPICORMIC GROWTH BANDS AND CYCLIC GROWTH BOOSTS AND THEIR RELEVANCE TO RECONSTRUCTING THE ORIGINS OF TIMBER.

Oaks growing in a "coppice with standards" environment usually produce whorls of tiny branches low down on the stem when the coppice is cut and light becomes available at ground level. In theory this should produce bands of small knots in timber cut from the lower logs of such trees. The features can sometimes be seen in modern planks cut from oaks grown in these environments but it may be very hard to see this in ancient timbers. However detailed tree ring studies may reveal periodic growth boosts that would be most simply explained by the effects of a cyclic reduction in the competition of underwood and standards (M. Bridge Pers Com.). Unfortunately this is a new branch of study for tree-ring specialists and no large body of comparative data exists.

APPENDIX - 3

CALCULATING THE WEIGHT OF PARENT LOGS AND FINISHED TIMBERS.

For this study the key concern is the weight of oak timbers in relation to the logistics of ship and boat building and the ancillary trades. The standard specific density value used for oak here is 1.073 (see Millett and McGrail 1987:106). That is a cubic metre of freshly felled green oak heartwood is taken to weigh about 1.073 tonnes. But again this must just be taken as a working value as the speed which an oak grows greatly effects the weight of timber it makes. Fast grown oak is denser (this also applies to ash, Fraxinus excelsior) than slow grown oak so much so that green, fast grown oak heartwood actually sinks in water. The bark, bast and sapwood are less dense than the heartwood and thus in small logs the effective density is less than in large. Branchwood such as that used for boat frame timbers, is often less dense than stem timber. Thus the weight calculations given in this study are rough approximations only, some attempt has been made to allow for the lower density of sapwood and bark for timber in log form and the figures are normally rounded down for ease of comparison.

The calculations are made in the obvious way to obtain volume thence weight, for parent logs the calculation is Pye x R squared x length (3.14 x radius squared x length) then multiplied by 1.073 to obtain the weight in tonnes. Again this will only produce approximate figures as logs normally taper and are often far from round in C/S.

APPENDIX - 4 LIST OF EXPERIMENTAL ARCHAEOLOGY PROJECTS CARRIED OUT IN PART OR ENTIRELY TO INFORM ASPECTS OF THIS STUDY

Note in all these projects the tools used were the nearest recent equivalents eg. An English coopers broad axe for a Late Saxon 'T ' axe etc. The materials used were worked green using techniques based on detailed archaeological recording wherever possible. Notes in the form of log books were kept for much of the work. And photographic records made, with the addition of video on some occasions. Regular bouts of work every year since 1988 were also designed to serve as training exercises and public demonstrations of aspects of nautical archaeology and early woodworking as a whole . Through out this work I have been assisted by several archaeological colleagues some of whom have also been practical woodworkers such as R. Darrah. All these colleagues have taught me much. Only the major projects are listed here. Smaller projects such as making high quality items for museum display or some of the archaeological television programmes are not listed.

1988

Building or hewing a small poplar dugout boat as practice for building a larger oak boat.

1988-9

A replica of the Clapton C10th dugout boat is built (Chapt.5) primarily as an unfunded research project in ancient woodland on the edge of London (Goodburn and Redknap 1988). Displayed next to the original conserved find for several years from 1991. It has also been used for many trials (with loading and trips up to 16 Km) and demonstrations since, particularly with children, currently on long term loan to the Wildfowl and Wetland Trust for a display on wetland living next to a coracle also made by this author.

1989 (currently halted)

A replica of the Kentmere 1 extended dugout was started following the detailed reinvestigation of the original vessel remains and archive for this research (also unfunded). Insights gained into hewing an awkward dugout hull form and how it distorts. Experiments in radial cleaving small oak boards using wooden wedges alone were carried out from 1989, initially lead by R. Darrah. Experiments included using one old iron axe to start the split, not using the axe, using wedges of different sp. such as oak, ash , fruitwood and yew, cleaving from the but of the tree or from the top, starting at the end of a cleft section or 1/3rd in etc. Cleaving down to 1/32nd clefts was achieved just using wooden wedges to open the splits. The boards generally produced were rather wider than those actually used for the original vessel and were cut down to fit. Also some boards were made using the froe and break method for the final split to 1/32nds. Experience was also gained in trimming green cleft boards. The work has informed the study of the original vessel (chapt. 6, Goodburn 1992b). The NAS gave a grant for the forging of the iron lap nails.

Currently the base has been built and several boards added. It is hoped to complete the project after the end of this study and use the vessel for educational display and serious trials before offering it on loan to Liverpool Maritime Museum which is relatively near the find spot.

1989-91

A replica hull section at life size, was built of the Roman Blackfriars 1 vessel. Relevant to this study for the experience it provided of finding and hewing large curved timbers (similar to medieval cog framing) and learning the technique of see-sawing planks also used in medieval shipbuilding.

1989

Assisted with and advised on the building of a replica of the large Iron Age Poole dugout, at the Cranbourne ancient technology centre and nearby woodland.

1990

Leading a project to build a reconstruction of the small 8th century AD Loch Doon 1 oak dugout for the Scottish fisheries museum assisted by Maritime Studies students from St Andrews University. The work caused a reappraisal of the original find.

1991 onward

Running introductory practical training courses for archaeologists historians and others on aspects of woodwork from Prehistory to the 19th century. This involves experiments in cleaving, half log building timbers of Saxo-Norman type, radially cleaving baords etc. Also hewing and sawing beams, joint cutting, treen work making bailers, paddles etc and roundwood working.

1993

Building a reconstruction of the 9th century Llangorse 1 oak dugout for the Time Team archaeology programme.

1995 onward

Regularly assisting the Mary Rose Trust with displays of aspects of Tudor shipwrightry, cleaving boards , sometimes with steel wedges sometimes not, double trestle sawing planks and beams, and hewing knees and crotch floors similar to those used for the Mary Rose. Also experiments in making treenails etc tools used of Tudor type.

1995

Leading and starting a project to build a reconstruction of the Shapwick Iron age oak dugout. This involved training a local team to continue the work.

1996

Building a life sized hull section of the Dover Bronze Age boat for research and display. Involved cleaving oak logs 3m long 1.15m diameter with wooden wedges alone. Making yew withies and working large oak timbers with small bronze tools.

1997 onward

Periodic involvement in medieval and Roman style carpentry work involving hewing straight timbers with varied tools and sawing them using see-sawing, double trestle, tripod, or pit-saw methods (fig.97.). Learning something of the mysteries of medieval carpentry such as layout and joint cutting. Also experimenting with the different approaches used by Roman carpenters to make display sections of house walls closely based on the archaeological material.

This has involved hewing timbers up to 6m long and 0.45m accurately square and true, with medieval or Roman style tools.

1997 onward

Running practical training courses for students of the Southampton Maritime Archaeology dept. involving many aspects of nautical woodwork from treenail making to , making ship board to making boat building equipment such as 'nippers'.

1998

Building a small medieval style clinker hull section to learn more about the sequence of strake hanging, and clenching rove nails using a dolly and chisel peen hammer only. This showed that the bruised triangular nail tips resulting are indicators of clenching near by. They were then identified on X rays of corroded iron from the medieval shipbuilding site of Smallhythe, Kent.

2001

Leading a team to build a reconstruction of the 8th century AD Amberly 3 half log dug out boat for the Weald and Down Land Open Air Museum. Provided insights into building half log dugout boats.

It should also be noted that before and during studying for a first degree in archaeology and the first 3 years after having obtained it this author, informally experimented with building several small traditional boats using simple methods used in the late 19th century but often including hewn grown framing etc. These included; two clinker prams one in the Holmsbu style, three flat bottomed clinker sided skiffs , to coracles and two currachs. Work also continued on the repair and restoration of traditional English wooden vessels of several types, and working as a dock carpenters assistant in Shoreham docks in the late 1970's.

APPENDIX 5 NOTES ON RECORDING AND RECOGNITION OF TOOL MARKS

What follows are some brief notes on what is a new field in archaeology interms of systematic research, there is as yet no standard work to which one can refer. Though the notes are concerned with the recording of timbers from waterlogged sites some generalities may be applicable to recording timbers in standing structures.

Though many post-depositional processes , such as partial decay and flowing water abrasion, tend to remove traces of woodworking, protected areas can usually be found where they are preserved to a greater or lesser extent. Even the fine detail of an individual tool mark can survive, in ideal conditions, for periods in excess of 100,000 years, as in the case of the Palaeolithic Clacton spear tip. The excavator should expect marks to survive when the following conditions occur on site-

1/ The best case, often encountered on waterfront sites, or in moats, pits, or wells, is to be expected when timbers are encoporated in very wet, cushioning, peaty deposits.

2/ In standing buildings ancient timber surfaces can be well preserved where they have been protected from the weather and insect or fungal attack., such as under the tarry soot on the roof timbers of a Medieval hall.

3/ Tool marks will survive on timbers that were originally exposed to flowing water only where other timbers or silt have provided a barrier to the abrasive force of the water.

4/ Occasionally ancient timber surfaces are preserved by being covered in materials such as tar or plaster, or perhaps the negative impression of a worked surface might survive as a void.

RECORDING TOOLMARKS.

In recording tool marks on archaeological wood a sampling approach has to be taken, the principal of which is to seek out the best preserved examples of any one type of mark and record those. Obviously sampling is particularly important in rescue conditions. Listed below in point form are some stages that can be used to record this dimension of early woodworking, which must follow on from the general site recording. Gentle cleaning of well preserved surfaces is essential if the fine detail of ancient marks is not to be lost (and modern ones added).

1/ Search the surface of a well preserved timber looking for the best preserved facets, these will often occur where the woodworker allowed their tools to dig into the timber a little too deeply. Most facets are shallow and only partially mimic blade edges that formed them.

2/ Make a one to one measured sketch or tracing of the mark or marks and record on the 1:10 or other appropriate drawing where the areas you are recording are located. This is important to establish the mode of use of a particular tool, ie. was there room enough to swing an axe at this point. Where appropriate use arrows to show the direction of use. The width accross the end of a facet is the crucial dimension as it will mimic the width of the tool blade.

3/ Use detailed photography with oblique lighting to highlight the general appearance of the marking, this alone does not suffice as a total record.

4/ If the marks are particularly well preserved it may be worth taking impressions of them which can be done relatively quickly and then provides a durable 3d record of the shape of part of the woodworking tool. The advice of the conservation department should be ~~sort~~ SOUGHT here. The small areas required can be easily moulded over night in damp conditions with record sketches being made to show where each labeled impression was taken. It may sometimes be possible to identify individual tool signatures on a group or related timbers, providing insights into ~~into~~ workshop practice etc.

COMMON MISTAKES IN IDENTIFYING TOOL MARKS.

1/ Oak and some other timber can grow with a rippling grain which when seen in planking can give the appearance of saw marks, as the ripples can be seen to run accross the width of the plank. Saw marks tend to have more jagged edges and are often closer together than ripples in the grain, and they will not appear on abraded timber.

2/ Nicks in the edges of edge tool blades cause ridges to appear following the direction of cut (axes, adzes, planes etc.) which are often confused with actual facets (fig 1,a).

3/ "Chatter marks", small parallel ridges left by scraping or shaving tools can often be confused with saw marks, but they are usually short, slightly rounded in profile and do not run all the way accross a face (fig 1,g).

4/ Marks can transfer from one timber to another when the weight of the over burden presses down hard on two timbers in close contact with each other. This can produce confusing results.

WHY SHOULD WE BOTHER TO RECORD THIS KIND OF DETAIL.

Given a broad dated sample it will be possible to say when particular tools came into common use and something of how they were used and what form they had. The working practices of woodworkers, carpenters, boatbuilders, wheelwrights and others are little known in the early periods and this is one of the areas which will yield most new information. Wood was the most common material in daily use in Londons past but the study of this technology is still in it's infancy, despite the large quantity of timber that has been excavated. As most archaeological timber will not be kept for future display and research excavators are bound to make the fullest record possible of this diminishing resource.

CAPTIONS TO FIG 1- SKETCHES TO SHOW-

a/ "Typical" axe or adze facets, showing the gap ridges made by a nicked blade and partial and nearly complete facets. Axe and adze marks are difficult to tell apart.

b/ Chisel or mortiseing axe marks.

c/ Auger holes are often found in the bottom of mortises, various tip forms are known, which will leave distinctive marks.

d/ A planed moulding, occa sionally found on Roman or Post-Medieval timbers.

e/ Hand saw marks, note the changing angles and very varied distance between indavidual cuts.

f/ Circular saw marks are modern!

g/ Chatter marks can be left by a scraping or shaving tool, they will usually be accompanied by long itudinal striations.

h/ Gouge or gouge adze marks will often be found on hollowed surfaces such as those in dugout boats or drains.

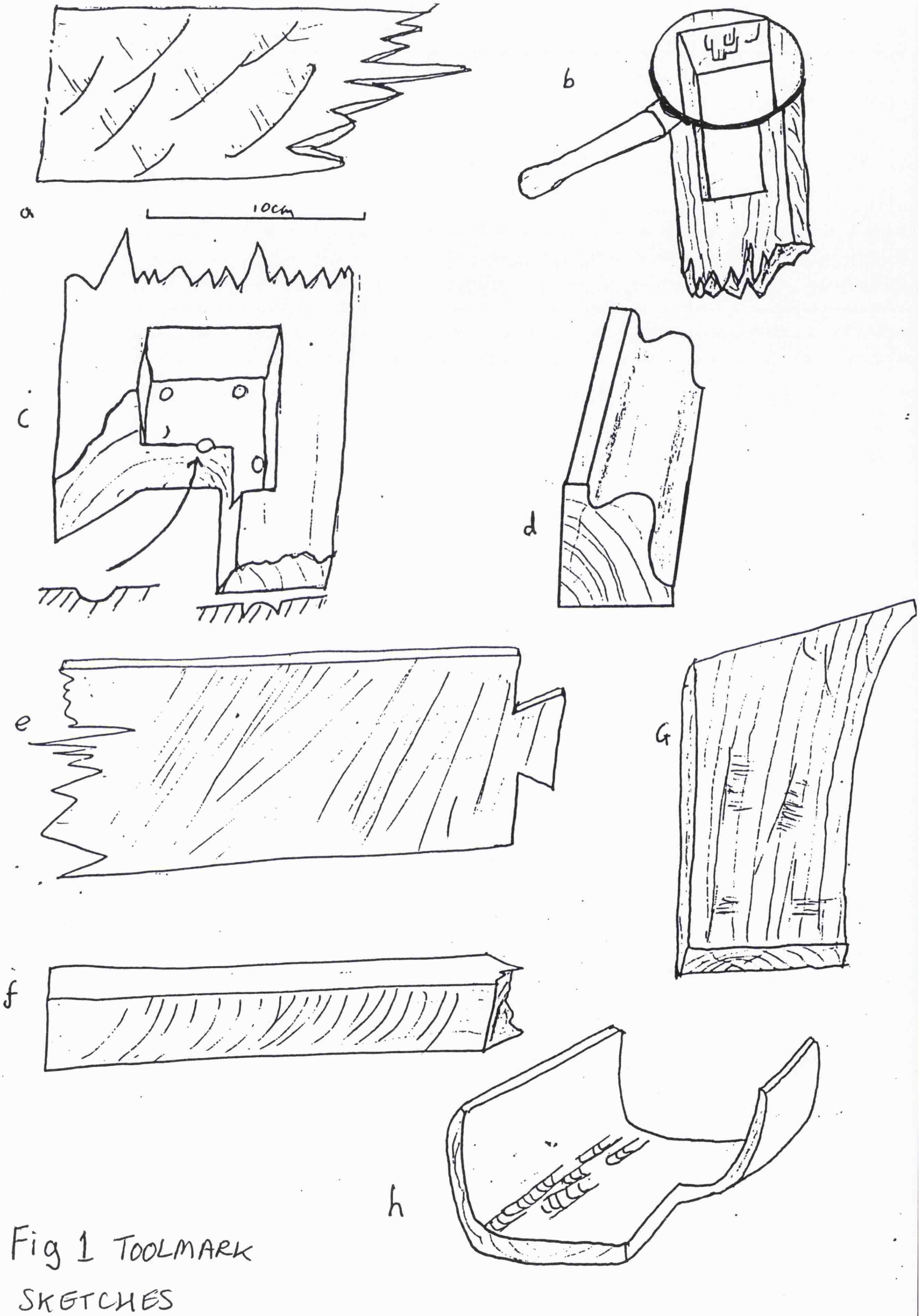
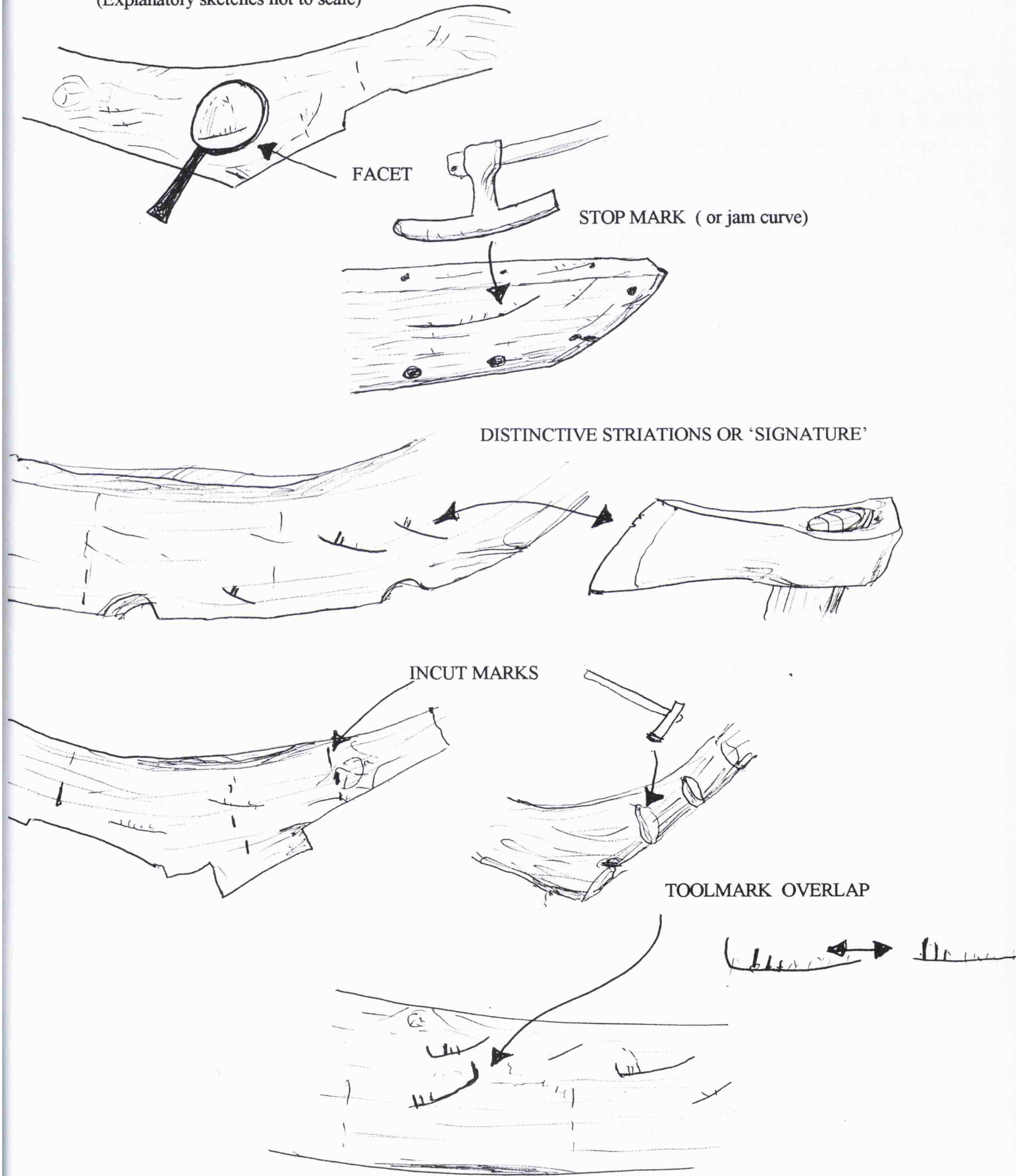


Fig 1 TOOLMARK SKETCHES

Fig. 2 TOOLMARK TERMINOLOGY USED FOR RECORDING MATERIAL REFERRED TO IN THIS STUDY

(Explanatory sketches not to scale)



APPENDIX -6 AN ANNOTATED LIST OF THE KEY c. 900-1600 AD NAUTICAL WOODWORK CONSULTED FOR THIS STUDY

NOTES

This list is not intended to be a full gazetteer of ship and boat fragments and more complete finds of the study period but simply a list of the archaeological material consulted first hand for this study (but very small decayed timbers with few diagnostic features have been excluded). It is intended that it should indicate the general form of the material consulted and convey something of its volume. Here 'material' includes detailed site records but not published accounts which are dealt with in chapter.2 and where relevant through out the main text.

An attempt has been made to quantify the material in terms of an- estimated minimum vessel represented number (EMV No.)- but in some circumstances this number may be unavoidably inflated. Where fragmentary finds of broadly similar type and date are found on sites in close proximity they may sometimes have derived from the same broken up vessel or vessels of similar size and style. In some cases a common origin in the same parent vessel has been obvious (eg. the Frisian boat timbers from different trenches excavated at Bull Wharf, City of London Chapt. 7) but in the vast majority of cases it is not and the timbers have therefore been considered as fragments of separate vessels. Some attempt has also been made to quantify the material examined from any one site for this work. A 'small' collection being approximately 1 to 3 vessel boards or planks, less than 2m long, or 1 to 3 incomplete frame elements. Anymore material than this from one site has been listed as 'large'.

The level or quality of first hand examination of the material has also been listed using the following symbols for brevity;

\# = woodwork examined in detail and wholly or partially recorded by this writer,
\+ = examined briefly by this writer; during the movement of the woodwork in conservation, on site, or during a 'behind the scenes' stores visit, but recorded by others,
* = unpublished site and archive records consulted,
$ = woodwork viewed on public display in a museum setting.

EMV No. = the estmated minimum vessel represented number, (see above).

CoL = City of London. Find spots in other areas given their most common site names and a 'site code' if known.

The publications referenced are the principal accounts that exist only, other detailed sources are cited in the main text where relevant.

The dating given is generally through tree-ring study of the timbers themselves 'direct tree-ring-dating' or of closely associated woodwork 'indirect tree-ring dating'. Otherwise dating is derived from associated finds or historically dated strata. Where evidence of a provenance is noted it is derived through tree-ring study, and or the existence of apparently diagnostic regional technical features. such as 'sintels'.

The nautical timber assemblage entries are listed alphabetically by first letter of the site code where known or of the commonly known site name where not.

DUA = Museum of London Dept. of Urban Archaeology; DGLA = Museum of London Dept. of Greater London Archaeology; MOLAS = Museum of London Archaeology Service, the amalgamated successor to the above, covering all of the London region and its immediate hinterland.

THE LONDON FINDS

ABB 86- Abbots Lane #, *; This N. Southwark waterfront trial excavation yielded a large amount of articulated, clinker boards from a medium sized craft. It was dated by associated finds to the late medieval period. Excavated by the DGLA. EMV No.1. (Goodburn 1991a).

ABB 87- *; (excavation adjacent to above 1 year later). Due to confusion in the labelling of materials this material may be derived from parts of the same slabs of reused clinker boat boards as the above. In addition to the large slabs of boards a number of similar loose fragments were retrieved from the same or similar vessels. Tree-ring study showed that the radially cleft oak boards and repair tingles derived from local, N.German and SE Baltic areas, at the end of the 14th century. That is the parent craft was locally built but included some foreign cleft oak board, possibly in repairs. Excavated by the DGLA. EMV No. 1. (Marsden 1996:107).

ABB 88- *; (watching brief adjacent to above, following year). A small quantity of loose, poorly stratified oak clinker vessel boards were found, one was directly tree ring dated to felling c. 1600 or a little later. Excavated by the DGLA. EMV No.1? (Marsden 1996:173).

ABO 92- Abbots Lane, #, *; This large Southwark waterfront site lay on the Thames frontage to the NW of the previous Abbotts lane sites. It yielded a large collection of reused, articulated clinker ship boards. These fell into three groups, including one heavy board fragment of SE Baltic oak. All this material was dated either by direct tree-ring dating, associated finds or on topographic grounds, to the late 14th century. A large quantity of sawn oak, carvel ship planking, and one carvel vessel frame timber were also found. A slab of sawn oak planking with unusual 'shiplap' rebates was also found. The last two timber groups were dated indirectly associated finds to reuse in the mid 16th century. Excavated by MOLAS. EMV No 6. (Archive report only Goodburn and Minkin 1996).

BC 72- Baynards Castle, *; This large CoL waterfront site, yielded 1 reused, joggled frame timber from a clinker built vessel. Dated by associated finds to the 14th century. Excavated by the GuildHall Museum. EMV No. 1. (Marsden 1996:126).

BTH 88- Bethel Estate, *,+; This Southwark site yielded a large collection of small articulated slabs of radially cleft oak clinker boat boards and loose examples. They were directly tree-ring dated to the late 16th century. Excavated by the DGLA. EMV No. 2? (Marsden 1996:160).

BEY 95- Bellamys Wharf, #; This large waterfront site in Rotherhithe E. London, produced a large collection of assorted reused carvel ship timbers including frame elements, keel and stem timbers, rudder posts and a knight head. A section of articulated clinker boat boards, was also found. These nautical timbers were closely dated by associated pottery to reuse in the 1660's. Therefore they probably derive from vessels built just after the nominal end of the study period. Tree-ring dating was unsucessful. Excavated by MOLAS. EMV No.4. (Saxby and Goodburn 1998).

BIG 82- Billingsgate. *; This large CoL waterfront site yielded small quantities of reused NFW style and two small sections of rivetted clinker boards. Indirectly tree-ring dated to the late 10th to early 11th century, with one section of rivetted board being directly tree- ring date to the late 12th to early 13th centuries. Excavated by the DUA. EMV No.3. (Marsden 1994:153).

Blackfriars 2 Boat +; Part of this wrecked but relatively intact 17th century clinker vessel river vessel was lifted in 1969. Small, dried, oak frame elements from this lightly built craft were briefly examined. Excavated by the Guildhall Museum. EMV No. 1. (Marsden 1996:145).

Blackfriars 3 boat. *,+, $; This relatively complete medieval clinker built river barge (or 'shout') was excavated long before this authors involvement in the field, in 1970. It had sunk near the mouth of the river Fleet in the SW corner of the City. Some very dried out fragments of the vessel were very briefly examined, and the remains as now displayed in the Shipwreck Heritage Centre, Hastings have also been viewed. The vessel is directly tree-ring dated to c. 1400. The excavation was carried out by the Guildhall Museum under P. Marsden. EMV No.1. (Marsden 1996:55).

BOY 86- Former City of London Boys School site. #, *; This CoL waterfront site yielded a very large quantity of assorted timbers, mainly cut into short lengths, from medium sized to very large carvel built vessels. These included; framed elements, planking, sealing, deck elements, knees etc. Also found small quantities of very decayed clinker boat boards. The reuse of all the elements were dated by associated finds and historical topography to c. 1660's, with a few pieces to c.1690's. Thus, most of the material is probably a little too late to be directly included in this study but provides useful demonstration of post-medieval changes in nautical technology. Excavated by the DUA. EMV No. 3+. (Goodburn 1991a:112).

BRI 78- Bridewell *,+; This Col site, yielded a small quantity of reused clinker boat planking dated by associated finds to the 14th century. Excavated by the DUA. EMV No.1. (Marsden 1996:126).

BUF 90/ UPT 90- Bull Wharf, #, * ; This large CoL waterfront site, excavated in 3 phases, yielded a large assemblage of reused articulated and isolated clinker hull boards, and some frame elements, fittings and gear from several medium sized to large vessels. Various styles of construction were clearly represented; the New Fresh Wharf, and Graveney English traditions, a local craft in a more S. Scandinavian tradition, and parts of a medium sized Low Countries vessel built in the proto-hulk 'Frisian' style, with an expanded dugout bottom. The hull boards included hood-end sections. The framing elements included small fragments of joggled clinker vessel framing, 2 knees and a possible 'bitr'. Fittings included a charred mast step, a possible mast prop ('myke'), and the blades of 2 oak oars or paddles. All the material is either directly or indirectly tree-ring dated to the 10th to 11th centuries AD. Excavated in stages first by the DUA, then MOLAS. EMV No. 8. (Goodburn 1994a, and in Ayre and Wroe-Brown et al in prep.).

CU 72-, Customs House, *; This large CoL waterfront site yielded a large quantity of reused, articulated clinker hull boards from one medium sized vessel. These were directly tree-ring dated to the 13th century and given a local provenance. A slightly later reused frame element was also found. Excavated by the DUA. EMV No.2. (Marsden 1996:41).

FW 84- Fennings Wharf *, +; This large Southwark waterfront site at the S. end of Historic London Bridge, yielded, a short length of reused, articulated keel and garbords from a medium sized to large vessel. The garboards were fasten with turned iron nails rather than rove nails or treenails. A short length of wide, thick plank, possibly part of a wale of some type, was also found. All the timbers were oak and were directly tree -ring dated to the 11th century, and appears to have been of relatively local timber. Excavated by the DGLA. EMV No. 1. (Marsden 1994:156).

G&S 88- Gun and Shot *, +; This Southwark Thames side site yielded a small slab of reused clinker ship boards. They were of radially cleft oak up to 60mm thick, with moss luting and treenails with central wooden pegs ('dottels'). The tree-ring study dated the parent vessel to the late 14th century and provenanced the timber to the SE Baltic. Thus, the parent vessel may have been of foreign origin or have been built of imported boards. A large quantity of small slabs of local clinker vessel boards were also found and directly tree-ring dated to the late 16th century. Some of the planking was of sawn elm. Excavated by the DGLA. EMV No.2? (Marsden 1996:118, and 167)).

HOR 86/ HOR 88, Kingston Horsefair, #, *; This Thames waterfront site in SW London, in the historic river town of Kingston was excavated in 2 phases. The work yielded; very large articulated slabs of clinker boat boards, from three medium sized to large vessels, the Kingston Nos. 1,2, and 3 boats. The board slabs found varied between 0.7m and about 16m long and up to 5 strakes wide. Most of the slabs of hull boards were over 5m long. Additionally a small amount of eroded small boat boards, possibly treenail fastened, were found. Importantly, evidence of a near by boatbuilding site also came to light in the form of a radially cleft board offcut and three roughed out oak knees, laid together and then abandoned on the foreshore. All the material is directly or indirectly tree-ring dated to c. 1300-1350 AD. Excavated by the DGLA. EMV No.4. (Goodburn 1991a:108, Potter 1991.)

JAC 96- Jacobs Island, #; This large waterfront site in Southwark, yielded 4 reused, articulated sections of clinker boat boards. These were directly tree-ring dated to felling c. 1600 AD. Later 17th century ship plank fragments, sections of reused spars and some shipyard debris were also found. EMV No 3+. Excavated by MOLAS. (Goodburn In Press).

KIB 97- Kingston Bridge #; This Thames waterfront site
in SW, London, yielded a small collection of eroded articulated clinker boat boards. These were dated by associated finds to the later medieval period. Importantly, a slightly trimmed curved oak log was found with oak board offcuts. These appear to be abandoned raw materials from a near by boatbuilding yard of c. 1350 AD (also see Hor 86 entry). Excavated by MOLAS. EMV 2.
(Archive summary only, Goodburn 1997 unpub.)

LTS 96- Three Cranes Wharf #,*; This small CoL waterfront site yielded 1 fragment of reused clinker boat board with a tingle. Dated by associated finds to the late medieval period. Excavated by MOLAS. EMV No. 1. (Archive note only, Goodburn 1996 unpub).

MFB98- Millenium Bridge # bankside Southwark This waterfront excavation , starting in 1999, revealed a series of timber river walls and watermans's stair constructions. Several of these structures contained reused boat, barge or ship timbers. Most of the material excavated falls outside our study as it is of the late post-medieval period including parts of the bottom and sides of a late 18th century river barge and a number of carvel ship hull planks, and deck timbers. However, the earlier material is proving to be of considerable interest . In a partially dismantled timber framed river wall built in 1583 AD (tree-ring dated) the remains of part of what had clearly been a punt- like up river or 'west country' type barge was found . The very surprising feature of the construction which kept the planking of the vessel together was that the pit sawn planks of oak and elm were edge joined with small oak free tenons in a similar way to that used in the late classical Mediterranean. A trace of a simple oak floor timber was also found , which had a bridle joint for a side frame element The timber of the edge of the bottom or chine was still spiked on to the edges of the bottom slab at an angle of c. 10 degrees. Traces of the joining of the bottom to the square sloping bow or 'swim also survived. Interestingly the hull and sides fragments of the flatbottomed late 18th century barge were also edge joined in a similar way. These finds were the first to be made of river vessels built in this most unusual style and the material is still undergoing study. This is why together with its very recent finding date, it has not been included in detail in this thesis . Small fragments of oak clinker vessel planking were also found in a slightly earlier river wall. An interim report will appear soon (Late 2002). Excavated by MOLAS. EMV No4+.

MGS 96- Magdelen St, #, *; This medium sized excavation in a silted tidal channel of NE Southwark, yielded, a large quantity of reused, articulated, cleft and sawn oak clinker boat boards. Also found was a sawn elm clinker boat plank, and short lengths of reused, carvel ship frame elements, of oak, and a short length of reused elm boat keel. The reuse of all the nautical timbers was dated by associated pottery, including a date stamped example to the early 17th century, tree-ring measurement was unsuccesful. Evidence of wear and repair suggests that many or all the timbers derived from vessels built in the late 16th century or around 1600 at the latest. Excavated by MOLAS. EMV No.4. (Archive report only Goodburn In Press).

MOR 88/MOR 87- Morgans Lane, +,*; This large site was part of the Hays Wharf project and included a large part of a moat just south of the Thames frontage in N. Southwark. It yielded a large quantity of reused, articulated slabs clinker boat planking of sawn oak and a mixture of cleft oak and sawn elm, also including a hood end section. It was argued that the hood end section derived from a reverse clinker built boat. It is suggested here that it actually derived from the bluff bows of a clinker lighter, conventionally clinker built (chapt 7). The planking and boards are directly tree-ring dated to the late C16th. Excavated by the DGLA. EMV No. 2+?. (Marsden 1996:169).

NFW 74- New Fresh Wharf, +, *; This large CoL waterfront site yielded a large group of articulated clinker vessel boards, 2 knee fragments, a possible wale and a floor board were found lying on a foreshore. The material became the epponomous material for one style of Anglo-Saxon boat building in which the clinker hull boards were fastened entirely with treenails (the 'New Fresh Wharf' or 'NFW' style). Directly tree-ring dated to the 10 century. Excavated by the DUA. EMV No. 1. (Marsden 1994:141).

PLS 94- Parliament Square, #; This site in Westminster central London, yielded 3 short lengths of reused planking from a vessel built in the cog-style. The fragments were tree-ring dated to felling in the early to mid 13th century. Excavated by MOLAS. EMV No.1. (Goodburn and Thomas 1997).

RTH 96- Rotherhithe Shafts #; This small waterfront site in Rotherhithe E. London, yielded a small quantity of reused, carvel ship frame elements, planking and spars. The reuse of the earliest of these, is dated by associated finds to the c. 1630's. Thus, the timbers probably originally date to c.1600. There is a possibility that some timbers may derive from the famous New World Pilgrim ship Mayflower. Excavated by MOLAS. EMV No.4. (Goodburn in Press).

SYM 88- Symonds Wharf *,+; This large Thames frontage site in N. Southwark, yielded a large quantity of reused, articulated clinker ship boards. Some of the heavy boards from a large vessel (the thickest yet found in the London region) were directly tree-ring dated, and provenanced to the SE Baltic. A fragment of framing was still fastened to one hull section in situ but was lost before tree ring study, by analogy with paterns of use of local 'V' imported oak in late medieval English buildings we might have expected the framing oak to be local with some or all the boards being imported. Thus, it is unclear wether the hull sections derive from a foriegn built vessel or one built in England using, imported high quality boards. Excavated by the DGLA. EMV No. 1 (Marsden 1996:117).

TEX 88- Thames Exchange, #,*; Reused and 'loose' timbers of the following types were recorded: A large group of articulated, and individual clinker vessel boards. These were mainly in the New Fresh Wharf or the Graveney style, but include 2 small board fragments in a more Scandinavian style (having round, un-plugged nail shanks and plied luting). A moderately well preserved largely complete, reused Graveney style keel was recorded in sections. Two fragments of clinker vessel framing, and and a small 'U' shaped rib, possibly from an expanded and extended dugout boat were also dealt with. A large carved possible mast partner beam reused as land-fill was also recorded and initially thought to have been of nautical origin. However, the beam with a semi-circular cut out of about 0.45m diameter is thought to have been the support beam for a church spire 'mast' rather than one from a large ship. The material was either directly or indirectly tree ring dated to the 10th or 11th centuries. Excavated by the DUA. EMV No. 4. (Goodburn 1994a).

TL 74- Trig Lane +; This large waterfront site yielded small quantities of clinker boat boards similar to those of Blackfriars 3. Directly tree-ring dated to the late 13th to early 14th century. Excavated by the DUA. EMV No.1.(Marsden 1996:125).

TUR 95- Turks Boatyard, # *; This Thames waterfront site at the historic river port of Kingston yielded a small, articulated, reused, section of two main clinker boat boards from a medium sized vessel. They were were scarfed together and broadly similar to the boards of the Kingston HOR No2 boat. The two boards were directly tree- ring dated to the 13th century (last heart ring 1216, no sapwood), and interestingly one board appeared to have been of west country origin and the other from the London region. Excavated by MOLAS. EMV No.1. (Archive report only).

TWE 98- Tanner St. south, #; This Southwark tanneries, excavation yielded a small collection of reused, patched clinker boat boards, of both sawn oak and elm. Too few rings existed for tree-ring dating but associated finds indicate reuse in the 17th century suggesting a building date of the late 16th to 17th century for the boat fragments. Excavated by MOLAS. EMV No. 1. (Elsden 2001).

TYT 98- London Bridge City, #; This large Southwark site included timber lined fish ponds (a pike garden) in one of these ponds the 1st lining was composed of large sections of articulated clinker ship planking including some hood end sections. . The presence of many orloke holes showed that the vessel was a 'galley' of some form. However, the framing was clearly fairly closely set and heavy (c. 200mm sided) and the boards were about 40mm thick on average. The vessel was originally built in Ireland, with radially cleft, slow-grown, wildwood oak boards including at least one reused board. The original Irish boards had a distinctive ridge face on one side. Later the vessel had clearly been massively rebuilt in SE Wales or S. England using faster grown oak, radially cleft and see-sawn oak, and beech (not native to Ireland). Four main slabs of articulated boards were lifted and recorded in the summer of 1999. Part of the vessel was temporarily displayed at the Museum of London less than 3 weeks after the excavation. The remains constitute the first material evidence of a later medieval galley yet found in England. Directly tree-ring dated and provenanced to initial building in late 1260's in the Dublin region (Tyers 1999 Un Pub.). Many of the boards were quite well preserved such as the oak orloke plank on which the marks of the see-saw method clearly showed. The three remaining orloke holes were set surprisingly close together at about 0.72m, not leaving a great deal of room for the oarsmen. Excavated by MOLAS. EMV 2 (due to reused boards). (Archive summary in preparation by this writer and Goodburn Forthcoming d).

VAL 88- Fleet Valley project, #; This large CoL waterfront site lay along the E bank of the river Fleet. A small collection of 2 joggled clinker boat frame elements and a fragment of hull board from a medium sized vessel(s) was found reused. They were dated by associated finds and indirectly by tree-ring dating to the 12th and c. 13th centuries respectively. Excavated by the DUA. EMV No. 2. (Archive report only.)

VIT 96- Victoria Wharf, #; This large waterfront site at Limehouse, E. London yielded an abandoned carvel ship floor timber, and large parts of a reused, large ship rudder post, and quantities of shipyard debris. The material was indirectly tree-ring dated to the late 16th century. Excavated by MOLAS. EMV No. 2. (Tyler and Goodburn et al in press).

VIY 97- Vinegar Yard #; This Southwark tanneries site yielded small quantities of reused articulated clinker boat boards, a small quantity of carvel ship framing, and a section of oak clinker vessel framing. The timbers were dated by associated finds to reuse in the early 17th century, but due to wear, it is likely that the timbers were of c. 1600 date. Excavated by MOLAS. EMV No. 4. (Goodburn In Press.).

VRY 89- Vintners Place, #, *; This CoL waterfront site lay immediately to the east of Bull Wharf. Two small groups of reused articulated clinker boards were found together with some loose fragments. Two styles of construction were evidenced, the English NFW style, and a locally built more S. Scandinavian style. The separate sections of articulated boards in each style may derive from the same parent vessels as similar material found reused at Bull Wharf. Two substantial sections of keels from fairly large craft were also found reused. A small curved boat stem fragment was found lying on a foreshore layer and two sections of a side rudder were found used as land-fill material. All the material was either directly or indirectly tree-ring dated to the 10th and 11th centuries. Excavated by the DUA. EMV No. 5. (Goodburn 1994a,)

245 BR- Blackfriars Bridge Road, #,*; This site straddled a small, infilled, tidal channel to the south of the Thames in west Southwark. It yielded a small section of articulated oak clinker boards with a sawn elm tingle, a reused oak clinker boat frame element, and several small reused fragments of carvel vessel frames. The reuse of the timbers was dated to the C17th century by associated finds. As the relatively small parent clinker vessel was clearly old and worn it may have been built as early as the end of the 16th century. Excavated by the DGLA. EMV No. 2. (Goodburn 1991a.).

37BS- 37-46 Bankside + ; This Southwark Thames side site yielded a large collection of articulated oak clinker boat boards and loose examples. They were directly tree-ring dated to around 1500. Excavated by the DGLA. EMV No. 2? (Marsden 1996:160).

FRAGMENTARY AND RELATIVELY COMPLETE PLANKED BOAT AND SHIP FINDS FROM BRITAIN EXAMINED IN PERSON FOR THIS STUDY

N/B * denotes unpublished records only reviewed.

CAMBER SHIP FRAGMENTS, EAST SUSSEX- #; A small collection of oak timbers were found during shingle extraction near the mouth of the R. Rother, at Camber in 1988. They comprised carvel ship plank elements including a hood end fragment, and two small fragments of framing. The fastenings were mainly oak treenails with some iron spikes in the hood ends. The material is currently best paralleled by elements of the Studland Bay wreck of c. 1500 and reused carvel ship planks of the 16th century from site ABO92 London. However, the technical details could also be paralleled in later material. The dating relies on the historically known dating of the movements of the Rother mouth and associated shingle banks. Local researchers suggest a date for the loss of the vessel c. 1450 AD, if correct the remains are therefore the earliest material evidence for carvel built shipping in England. Too few rings existed for tree-ring dating. Salvaged by C. Bloomfield, Romney Marsh Research Trust. EMV No. 1. (Goodburn 1990).

COPPERGATE BOAT FRAGMENTS FROM YORK- #; A small collection of articulated clinker boat boards were found reused along side the river Foss during a watching brief on the famous Coppergate site. They were examined in detail post-conservation and were seen to be broadly similar to material from London later medieval sites. Most of the boards were radially split slow grown oak although one was fast grown and probably sawn. Tree-ring study dated them to the 14th century and interestingly showed that the slow grown boards derived from the SE Baltic region. The boards were iron rove nail fastened. Excavated by the York Archaeological Trust. EMV No. 1-2? (Goodburn 2000b)

DNB 93- NORTH BRIDGE, DONCASTER, S. YORKSHIRE, BOAT FRAGMENTS- #, Two small articulated slabs of clinker boat boards and some loose fragments were found reused on a waterfront site in central Doncaster, S. Yorkshire. They had iron rove nails and radially split oak boards. One fragment, from a relatively small vessel, included hood ends and possible evidence for a broken sheer line, and a treenailed inwale. The reuse of this slab has been finds dated to the 15th century. The second slab of thicker planking from the body of a vessel was directly tree-ring dated to the late 12th, and of apprently local origin. Work, including conservation, organised by J. Spriggs of the York Archaeological Trust/ English Heritage Wood Conservation Lab. EMV No. 2. (Archive report only).

GRIMSBY BOAT FRAGMENTS- *; Unpublished detailed field drawings and photographs were studied briefly of a moderately large section of articulated clinker boards. They were of radially cleft oak and were iron rove nail fastened. They had been finds dated to the late medieval period (D. Evans, Humberside Archaeological Unit pers com.). They appeared to derive from a much repaired vessel (Brief notes for archive only).

KINGSTEIGNTON BOAT, DEVON - * +; Unpublished records of fragments of this vessel found during clay extraction near the course of the R. Teign, were briefly reviewed. The surviving radially cleft oak clinker boards appear to derive from a flat floored clinker built vessel, with iron rove fastened laps. The need for further recording of what was lifted and the context of the find was highlighted, and a new sucessful effort made to tree-ring date the find. It is now dated to the 14th century. Now in Torbay Museum. EMV No.1. (Goodburn 1993d.).

MAGOR PILL HULK GWENT, SE WALES- +,*; Substantial remains of a small clinker built trading vessel were found in the silted entrance to a tidal channel just on the Welsh side of the Severn estuary in 1994. The clearly hulked craft was partially dismantled in medieval times. It was viewed in situ after the removal of most of the contents and some detailed field records were also reviewed. The vessel had a deeper keel than found to date in SE English finds and a vertical scarf of the stem to keel. However, other wise the vessel was similar in general terms to the Blackfriars No3 barge but with deeper more flaring, seaworthy sides. The boards of the hull were of radially split oak, fastened with iron rove nails. The framing was also of oak but some of the sealing planking was of radially split beech. The vessel was tree-ring dated to building in 1240 AD. The original hull boards and framing had the strongest matches (T values between 10.4 and 13.6) with the 'Southern England Master SDL curve' and sequences found at Gloucester. This strongly hints at building up the Severn in the English Marches, a point strangely ignored in the tree-ring study report. A board from another vessel had been used in repairs. A partial hull reconstruction was built, in modern materials, by Dr. E. Gifford. Excavated by the Glamorgan/Gwent Archaeological Trust. EMV No2. (Nayling et al 1998).

MARY ROSE WRECK- +; The largely intact hull of the carvel built warship Mary Rose was viewed rapidly during break in the current spraying regime and some woodworking details observed. The main structure of the hull is of oak, with some Elm, and a little imported pine. Limited examinations have shown that some frame elements were edge fastened as in frame first building, whilst much of the framing has no clear edge fastening. However, the in situ sealing obscures nearly all the framing. The main hull planking was of pit sawn oak, with the upper castles clad in cleft oak board, of English origin. Historical dating shows clearly that the vessel was built between c. 1509-1511, in Portsmouth, Hampshire. Some features of the hull such as; clearly misshapen areas, and the use of packing pieces on the framing and some seam laths could be taken to indicate that the shipwrights were still new to the new carvel ship building technology. Recently tree-ring studies have indicated that much of the timber used in her original hull was fairly local in origin, with some repairs at Chatham being of oak from the Kent region. Excavated by the Mary Rose Trust. EMV No.1. (No overall detailed account of the hull is available some information pers com. and Bridge and Dobbs archive summary of provisional tree-ring studies, un pub 1995).

MEDMERRY BOAT FRAGMENTS W. SUSSEX- #; A small collection of reused oak board fragments were found at the eroding Middle-Saxon coastal site of Medmerry near Selsey Bill in the 1930's. Dried fragments of which were eventually identified in Chichester Museum stores as treenail fastened, oak clinker boat boards. The small sample showed similarities to the material from New Fresh Wharf. The associated cooperage timbers were dated to a felling date range of c. 770 to 810. Surface collection by Mrs G. Clarke 1934. EMV No.1 (Goodburn 1987).

POOLE FOUNDRY SITE, POOLE- +, *; Excavations by Poole Museum archaeologists on this waterfront site in Poole SW England revealed several stock piles of both used and roughed out boat timbers. The collection appeared to have been part of a boatyard timber store, and included; roughed out and used clinker boat framing elements, roughed out knees, used and roughed out stems and baulks for planking and beam elements. The material was recorded in detail although some of the records of woodworking evidence made by S. Allen remain in the archive. The material seems to have derived from a yard building relatively small craft (<15m long) probably fishing and inshore general purpose vessels. The collection was dated by associated finds to the mid 15th century. (Watkins 1994).

SANDWICH SHIP- +, Sandwich , Cinque Port, Kent, Very recently this writer was able to visit a collection of large oak frame elements salvaged from this vessel which was exposed in a contractors trench in the early 1970's . The timbers were recently moved into the care of Dover Museum where they are now finally undergoing study and recording (G. Milne Pers Com.). They comprised axe hewn floor timbers, including several from the stern of the vessel. Large parts of a very large oak stem post had also been saved. The floor timbers were joggled showing that the vessel was clinker built. A floor timber with sapwood was found which proved to have just enough rings and a 14th century tree-ring spot date was obtained (M. Bridge Pers Com). More of the very large vessel is thought to lie buried where it was disturbed in a back channel off the main tidal creek leading into the historic port, which is thought to have been blocked of in the 15th century. Very recently fragments of very heavy framing and thick radially cleft oak planking were seen in the Charlestown Shipwreck 'Museum' Cornwall which were labelled as 'Sandwich ship'! These fragments are now undergoing research . EMV No 1.

SMALLHYTHE SHIP BUILDING SITE, KENT- *, +; The now silted up tidal channel close to Smallhythe is well kown from documents to have been the site of major ship building activities from the 13th to 16th centuries. It was subject to survey and trial excavations in 1998, as part of a Channel 4 Television 'Time team' archaeology programme. This writer was able to briefly examine used and unused rove nails, also corroded cut off nail tips seen on X rays of finds. These last items were recognised as debris from clenching rove nails for the first time as a result of experimental clinker hull section building carried out for the programme. Also viewed were some field records of a joggled clinker frame fragment found during the trial trenching. Possible edges of earth cut building slips next to the silted channel were also exposed. Excavated by the Time Team Team and associates. EMV No. 1. (Friel 1995:52 and G. Milne et al Forthcoming).

STUDLAND BAY WRECK- +,*,$; This vessel was excavated underwater in articulated hull sections in Studland Bay near Poole Dorset, SW England. It comprised large sections of the hull of a small carvel built ship, including section of hull side and bottom planking held together with treenailed framing, and part of the stem post assembly. Fragments of the vessel were viewed on display and in store in Poole Waterfront Museum. Excavated by the Studland Bay Research Group and Poole Museum Service. EMV No.1. (Hutchinson 19991).

SELECTED EARLY AND LATER MEDIEVAL DUGOUT BOAT FINDS FOUND IN BRITAIN EXAMINED FOR THIS STUDY

BUF90- Bull Wharf, City of London, # *; Two fragments of what appear to have been the large, expanded, oak dugout base to a Low Countries 'proto-hulc' of the 10th century were found reused at this site, as described above. EMV No.1. Excavated by MOLAS. (Goodburn forthcoming).

CLAPTON BOAT, LONDON- #, * ; This largely intact small dugout boat was found during building works in Springfield Park London Borough of Hackney in 1987, it was then brought to the MoL for recording. It has been conserved and put on display in Hackney Museum for several years. It was hewn from a whole oak log leaving punt-like ends, and a central bulkhead 'in solid'. It was originally c. 3.75m long. Many tool marks survived on the original surfaces. It was directly tree-ring dated to the mid 10th century. An accurate experimental replica was built in 1987-88, and provided some insights for this study (chapt. 5.). Salvaged by the DGLA. EMV No.1. (Marsden ed. 1989, and Goodburn and Redknap 1988).

GLASTONBURY 1, SOMERSET- +, This boat was found in 1884 and eventually taken to Glastonbury Tribunal museum. It was hewn from a whole knotty oak log, and given a box-like cross section with rounded ends. It was originally c. 5.5m long. The poor quality of the timber and flat boxy form, possibly skeuomorphic for a plank built vessel, perhaps hints at a Roman or medieval date? Dating is apparently to be attempted. Found during ditching. EMV No1. (McGrail 1978:195).

KENTMERE 1 EXTENDED DUGOUT BOAT, CUMBRIA, NW ENGLAND- *, # ; This abandoned or sunken small boat was found partially flattened in the silts of the drained upland lake of Kentmere NW. England in 1955. The oak dugout element formed the bottom, lower sides and solid block ends of the hull, which was extended with rove nailed, small, oak clinker laid boards, and had four inserted ribs. Other fittings included thwarts, oarlocks, and stabiliser logs. An experimental replica is nearing completion now (Chapt. 6, this study). The dugout element was c. 4.3m long. Excavated by DM Wilson and others. The boat was directly C14 dated to around 1300 AD. (Wilson 1966, and Goodburn 1992).

LLANGORSE 1 BOAT, BRECON, SE WALES- +,# ; This small dugout boat was lifted virtually intact in 1925 from the partly silted mere of Llyn Llangorse, SE Wales. It is now on display in Brecon Museum. It was hewn from a whole oak log, leaving a seat 'in solid' at the stern and a handle like projection at the narrower bow. The form was flat bottomed with flaring sides, and it was originally c. 4.65m long. The vessel has a 9th century date radio carbon date. An accurate replica was built in 1993 for Channel 4 TV's Time Team, and the National Museum of Wales. During that work the original vessel was re-examined and some new information came to light, concerning putative toolmarks and the size of parent log used by the builders. EMV No.1. (Fox 1926).

LOCH DOON 1 BOAT, AYRSHIRE, SW SCOTLAND - +, *, # ; This small oak dugout was found with other dugout vessels on the draining of the lake Loch Doon in 1823. It was reexamined during the building of a replica for the Scottish Fisheries Museum in 1991, and some new evidence came to light then. It is clear that the original boat had been abandoned during the last stages of building, and some diagnostic tool marks survived. The boat was C14 dated to 509 +- 110 but its is clear that at least 50 rings of sapwood were missed by the core and the vessel may thus date to about 550-560 AD +- 110. It was originally c. 3.45m long, with a rounded bow and square stern. An experimental replica was built and 'finished' for the Scottish Fisheries Museum Anstruther, with the help of St Andrews University Students and one of the team, M Lawrence compiled a dissertation on the project (Lawrence unpub. 1992). EMV No. 1. (Lawrence et al 1992)

WASDALE BECK BOAT, CUMBRIA- #, (also known as the Shap Fell boat); This small, fairly complete, boat was found during pipeline works in 1985 near the silted mere of Wasdale. It was conserved at the York wet wood conservation lab and held in store at the Windemere Boat Museum, where it was recorded in detail by this writer in 1990. Many clear toolmarks and a repair patch had survived. It was hewn from half a knotty oak log, and given pointed ends with a fairly flat bottom. It was originally c. 3.32 m long. A tentative date of early medieval to c. 13th century AD was suggested on the basis of the toolmarks repairs and form. A tree-ring felling date range was later found spanning c. 1250-1300 AD (C. Groves Pers Com.). Salvaged by the Lancaster University Archaeology Unit. (Archive report by this writer and comment in Chapt.5).

MOLSEY No. 2 BOAT, R. THAMES, SURREY- +; This boat was dredged from the the R. Thames near West Molsey, just W of London in 1891. It was briefly examined in Kingston Museum in 1993. Few diagnostic features survived but on the basis of the size and presence of one spoon augered hole a very tentative suggestion on Roman or later date was suggested. As most smaller English dugout finds are found to be early medieval when securely dated this was suggested as perhaps most likely. This was later confirmed by tree-ring dating to c. 950 AD (I. Tyers Pers Com.). Dredged out of the river. EMV No. 1. (McGrail 1976).

RELATIVELY COMPLETE VESSELS AND FRAGMENTARY BOAT AND SHIP FINDS EXAMINED IN PERSON FOR THIS STUDY IN NW AND N EUROPE.

L'ABBER WRAC, BRITTANY, FRANCE- $; Small sections of radially cleft oak planking from this vessel were on display and examined by the writer at the 'Douarnenez 1988' international maritime festival. They seemed broadly similar to English medieval material, and are finds dated to c.1500. EMV No.1. (L'Hour and Veyrat 1989).

BREMEN COG, NW GERMANY- $; The almost complete remains of this large seagoing trading vessel were viewed on display in its treatment tank before the treatment fluid became very cloudy. Of note was for this study was they use of saw (probably on trestles) hull planking, the use of turned nails. The distinctive use of moss-laths and sintels for waterproofing has not yet been found in clearly English built vessels. The find is dated to building in the 1380's and was not quite completed when lost during probable floods. EMV No.1. (Kiedel and Schnall eds 1985).

DUBLIN BOAT FRAGMENTS, EIRE- +; The writer has mainly had to rely on the published account for this study of this very important large collection of early and later medieval boat and ship fragments. However, a small quantity of the material was briefly examined in the National Maritime Museum conservation stores at Kidbrooke London. EMV No 5+ (of material briefly examined first hand). (McGrail 1993).

FRIBRODRE SHIPYARD SITE, FALSTER, SE DENMARK- +,$; The writer has mainly had to rely on the published summaries of excavations at this important 11th century ship building and repair site. However, a small quantity of the woodwork recovered from this site was briefly examined during a visit to the stores of the Roskilde Viking Ship Hall. This included; used oak frame elements, clinker board fragments of oak and beech, unused and used treenails of willow, mauls, treenail and larger wedges, and woodworking debris. Other material was seen on display during a separate visit to the museum. The excavators believe that some features of 'Slav' boat building were exemplified in the finds of treenail fastened clinker boards, and some small finds. Excavated by the Roskilde Viking Ship Museum. EMV No.5+? (Skamby-Madsen and Crumlin-Pedersen 1989).

GDANSK TOWN MUSEUM, POLAND $; One partially complete treenail fastened clinker built vessel of early medieval date was viewed on display. Several other boat fragments and wooden tools were also briefly seen on display. EMV No. 3+. Excavated by Gdansk town archaeologists.

HEDEBY SHIPS, N. GERMANY $; Long running excavations on land, and in the adjacent harbour area of this early medieval trading town on the German / Danish border have produced a wealth of material relevant to this study. The remains of three partially complete clinker built wrecks were found in the harbour and have been conserved. These were viewed by the writer on display at the site museum. Wreck 1., a very large narrow warship had radially cleft oak boards, often of exceptional length, with framing of oak and ash. Tree-ring study showed that the vessel was built in the 982 or just after, of local oak. Wreck 1 was carefully finished and of Scandinavian appearance and clearly a high status craft. Wreck 2, was of a quite different clinker vessel, more crudely built with boards of oak, beech and pine. The lower hull boards were iron riveted and the upper strakes treenailed at the laps. Tree-ring study of three of the oak boards suggests a dating of c. 970-80, and a reasonably local origin.

The vessel may have been a small trader or fishing craft. The lifted elements of Wreck 3 comprises parts of a large clinker built, deep-sea trading vessel. Principally the elements consist of framing, a keelson and bitr and some boards. Tree-ring study suggests a building date of c. 1025, with in the region. Interestingly, a wide variety of non oak species were used for the framing of the vessel from oak to alder, ash and maple. The shape of the timber apparently being more important than the other properties. Together with the wrecks a large number of ship and boat fragments were found, including boards, framing elements, and gear such as rigging. Some of this material was also displayed. Importantly many of these finds and debris such as, used and unused treenails and a tar mop, were found close to one of the jetties suggesting the location of a ship building and repair yard. Another important aspect of finds from the harbour area are two dugout boats, one of beech and the other oak. Both are C14 dated to broadly the Viking period, and both have solid bulkhead features. Thus, the finds cover vessels of a range of functions, status, and building style. Excavated by several different teams. EMV No. 5+. (Crumlin-Pedersen 1997).

KETELHAVEN SHIP ARCHAEOLOGY MUSEUM, CENTRAL NETHERLANDS-$, *; Some of the extensive material collections of that institution both displayed and stored material were briefly examined. The remains comprised a range of small to moderately large craft of later medieval and post medieval date. Several features were relevent to this study. Some material displayed cog-like features, such as the use of sawn oak planking, and moss-lath and sintel water proofing. Indeed, radially cleft oak boards were rare in the material viewed, only one Polder ship find then undergoing recording had an iron rove nailed, fully clinker built hull. Sections of early carvel built hulls were also briefly examined, and traces of the distinctive shell-first style of carvel building were seen. Some examples of detailed unpublished records were also seen. Mainly excavated by the Ketelhaven museum staff. EMV No. 10+. (many reports, some cited in the many text).

NYDAM OAK BOAT, NOW N GERMANY-$. The remains of this well known 4th century AD clinker vessel were examined on display at Schloss Gottorp museum, as the best preserved early example of clinker building accessible. The ceremonially deposited almost complete vessel was excavated in the 1860's in SE Denmark eventually ending up in Germany. The long narrow vessel was a principally for background information, as it technically dates from before the study period. It has some archaic features such as hewn cleats to which the ribs were lashed, no examples of which have been examined in the English material studied. During the visit it was clear that the assertion that only the upper strakes were scarfed was incorrect. The changing angles of the knots showed that other strakes were made of two or more cleft planks. Recent tree-ring study has confirmed this and provided a date in the 4th century AD (N. Bonde Pers Com.). Excavated by C. Engelhardt. EMV No. 1. (Rieck and Crumlin-Pedersen 1988:97).

POLISH NATIONAL MARITIME MUSEUM, GDANSK $,#; This museum houses a large collection of relatively complete planked and dugout boat finds built in a variety of styles. They date from the early medieval to post medieval periods. Of particular relevance to this study was a sunken cargo of the 15th century including radially cleft oak export boards. Gdansk is well known as one of the points of export of high quality wildwood, oak boards from the SE Baltic hinterland. Some of these roughly dressed boards could be examined in detail and dimensions, tool and other marks were hurriedly recorded by this writer (see chapt 8). Radially cleft oak ship boards of incredible quality over 8m long and c. 330mm wide were also displayed and apparently of 15th century date. This provides a contrast for the English produced materials (see chapt. 7). Excavated by various Polish maritime archaeology bodies. EMV No. 7+.

SKULDELEV VESSELS, ZEELAND, DENMARK- $; The hulked remains of five deliberately sunk clinker built vessels were excavated between 1957-1962 in the Roskilde fjord. The Roskilde, Viking Ship Hall where the conserved vessels are now displayed has been visited several times for this study, and for general background information, on the detailed examination of the material evidence of early boat and shipbuilding. The vessels are so well known and discussed in chapt.2 that only a few key points of direct relevance will be noted here. Of the 5 vessels No 1 was a large trading vessel, with mainly pine planking and though to have been built in Norway. No2 was a large warship, No. 5 was a smaller warship. No. 6 is of uncertain function. All the vessels have distinctive early medieval Scandinavian features such as light framing, the use of bitr, iron rove nails and frequent use of scratch mouldings. These features have been found to be rare in the material examined from England for this study with the exception of the fragments of 11th century long ship apparently similar to Skuldelev 2 from London (Sites VRY 89 and BUF90). Detailed analysis, partly displayed in graphic terms at Roskilde, has informed aspects of this study, such as the recording of toolmark evidence. Reconstructions of the No1, 3, 5, and 6 vessel have now been built, and all these projects are used to extend the displays of the original material. This work, most particularly the Roar Ege project involving the building of a remarkably technologically accurate reconstruction of the No 3 vessel has considerably informed this study. It was also one of the main spurs to the limited experimental work carried out for this study. The range of raw materials and species of timber used in the vessel is broad and has provided parallel data for the material found in England. Excavated by the Danish National Museum. EMV No. 5 (+ as some boards have been reused from other vessels). (Olsen and Crumlin-Pedersen 1978, Andersen et al 1997).

UTRECHT 1 SHIP, CENTRAL NETHERLANDS $; This large expanded and extended dugout vessel was excavated during building works in 1930. It was examined on display in the Centraal Museum of Utrecht for this study. The dugout lower hull was extended upwards and outwards after expansion with overlaping treenail fastened planks and thick wale timbers. Framing was then added. Some researchers have doubted that the base was expanded but the characteristic rising dish form and fissuring inside is indicative of expansion. The key importance of vessel for this study is as a parallel for the fragmentary 10th century proto-hulk elements found at Bull Wharf, London. The Utrecht 1 vessel is broadly dated to the 11th to 12th centuries. EMV No. 1. (Vleck 1987).

VAALE MOOR EXTENDED AND EXPANDED DUGOUT, N GERMANY $; This large expanded and extended dugout vessel was briefly viewed on display at the Schloss Gottorp Museum Schlesvig-Holstein. The key importance for the this study was to observe evidence of the use of expansion and inserted ribs in a vessel somewhat intermediate between a dugout and fully planked vessel in form. The vessel is dated just before our study period by c14 to the 2-3 centuries AD. EMV No 1. (Akerlund 1963:115).

END NOTE. The writer has also informally drawn upon numerous visits to innumerable museum displays and fieldwork on nautical woodwork of the prehistoric, Roman, Dark Age, later post-medieval and recent periods for general, and comparative background information. This information and practical examination of vernacular boat building in Britain and elsewhere over the last 25 years has not been formally listed in this appendix or explicitly drawn upon except where specifically cited in the main text. However, this long term continuing practical and research interest was the initial motivation for embarking on this specific study. It is also true that systems of detailed analysis of features such as toolmark and parent-tree reconstruction studies, are equally applicable in other related fields of research and there has been some cross fertilisation as a result (see chapt 9).

APPENDIX - 7 USES OF TREE-RING STUDIES IN BOAT ARCHAEOLOGY

This note is intended to list the potential uses of tree-ring studies for boat and ship archaeology research. Most of the uses are exemplified above at relevant points in the text, but here they are grouped together for easy reference. I am intebted to many tree-ring specialists with whom I have discussed the potential of their specialism, particular thanks are due to I. Tyers and N. Nayling.

List of uses of tree-ring research

1/ The most well known is that of absolute dating where timbers with more than 45 annual rings are required for sampling. Ideally the timbers are sampled where there is some remaining sapwood, or better still 'wane' or 'bark edge'. If the sequence can be matched against a dated reference chronology then a felling date date can be obtained to the nearest season rather than calender year eg winter 1161-2 or spring 1164. Sapwood allowances vary across Europe for oak , with more in the west than the east. In the SE of England the current allowance is 10-45 years. The species suitable for this work are primarily oak but recently reference chronologies have been built for beech and pine (*Pinus sylvestris*) (Nayling et al 1998). A minimum of perhaps 8 samples are required for dating ideally.

2/ If a match to a reference chronology can be made it may be possible to suggest which region of Europe or even which region of England the timber came from (eg. Bonde and Crumlin-Pedersen 1990). As regional reference chronologies become stronger the definition of sourcing can be sharpened. As awkward to move framing timbers are the most likely to be local to the building site and it is well known that boards or sawn plank can be traded over great distances (see Chapters 7 and 8), frame timber samples are to be prefered for this work.

3/ If the samples from many timbers of a vessel can be taken it may be possible to investigate which timbers derive from the same tree if the statistical match is of high enough quality. The potential of this use of tree-ring studies was realised early by McGrail (McGrail 1987:39). Recently this aspect of the technique was employed with great success by Nayling and Tyers in investigations of the 13th century coaster the Magor Pill boat (Nayling 1998).

4/ The technique can also be used to isolate repairs and rebuilds in cases where they may not be obvious otherwise. It may be possible to date and localise where that work was done. This has been achieved for the rebuild work of the Mary Rose in Chatham in the 1530's (Dobbs and Bridge 2000).

5/ Finally, tree-ring studies can be very useful to assist with attempts to reconstruct the treescapes used by the ship or boat builders or their suppliers. The absolute age of the parent trees can sometime be discovered, especially with timbers hewn boxed heart which have their wane preserved. However, with radially cleft boards used in clinker ship and boat building the core and outside annual rings will often be missing and due allowance must be made for them.

APPENDIX- 8 BRIEF NOTES ON RECORDING NAUTICAL TIMBERS

Experiments were made during the early stages of this study to devise a proforma record sheet for recording the most common class of medieval boat and ship timbers ie. clinker boat and ship boards and planks. The concept was to provide Y N tick boxes to speed up the work of recording details and make the results more easily computorised. They were given a trial with the Kingston Horsefair finds and found to be data accumulators that were slow and awkward to use. They were not persued further and the primacy of the heavily annotated drawn record on durable gridded film or direct tracing was acknowledged. Tracing was reserved for the larger articulated slabs of planks or boards especially where there was a chance that the elements would refit each other.

Tracing direct onto the surface of the boards and planks using polythene carefully aligned and pinned on to overlap if required was used with marked scale lines and waterproof felt pens. The rolls of polythene were then run through a plan copying machine and the scale bar dimensions checked for distortion. I:10 drawings could then be prepared from the copies with a fair degree of accuracy. The method is basically that dveloped by Mckee for the Graveney boat project in the mid 1970's (Fenwick ed. 1978). If the tracing is done on overlying perpex or glas sheets there is a greater risk of paralax error. Essentially direct tracing is a boatbuilder's method that gives one an immediate view of the often subtle curves of the boards or planks. Reduced paper copies of the strake outlines can then be glued to thin card and used for modeling the hull sections preserved. It is hoped that this is a process that will be attempted for some of the Kingston Horsefair material in due course.

Curved frame elements, keels knees and beam type elements were simply carefully drawn to scale either 1:10 or 1:5.

Photography was also extensively used for recording (Mainly by the Museum of London photography dept.) but it has not been used much in this thesis due to the problems of reproduction , although they are in some of the publications listed in the Bibliography (vol I).

APPENDIX -9 NOTES ON FASTENINGS

STRAKE TO STRAKE FASTENINGS

The types of lap fastening used in medieval clinker built craft were crucial features construction and have been interpreted as features of ethnically defined styles of construction (Crumlin-Pedersen 1997, Marsden 1994). The fragmentary finds from London provide evidence of a variety of styles of fastenings and how styles changed through the period.

PRE-CONQUEST LAP FASTENINGS

Four distinct styles of lap fastening (and waterproofing) are recorded prior to the late 11th century in England (Goodburn 1994a). The first two appear to be Anglo-Saxon styles employed in at least the SE third of England.

1/ The New Fresh Wharf style- The eponymous site was New Fresh Wharf, (NFW74), laps were fastened with headed willow or poplar treenails oak wedged inboard and moss luted (fig.92a,a,) medieval accounts imply willow was used). Finds of clinker boards of this type have been made on the following sites NFW74, BIG82, TEX88, VRY89, UPT90-BUF90, and a possible piece from ONE94 in London (Goodburn 1994a) these are tree- ring dated between about 900-970 AD (Tyers 1993, 1994). Similar lap fastenings must have been used in the clinker boat planking from the W. Sussex site of Medmerry, dated to around 790 AD. (Goodburn 1987). Curiously these features have been considered markers of Slav boatbuilding.

The treenails are slightly facetted but it is not clear what type of edge tool was used to carve them, but it may well have been a draw knife. They were always carefully made between 12-15mm diameter, and they had to be watertight. Occasionally a staining of the pale wood suggests that they may well have been lightly tarred before use. The inboard ends of the treenails were expanded with oak wedges set across the grain of the strakes to avoid starting a split. Thus, these treenails hold like wooden rivets, not 'pegs' or 'pins'.

Why use willow?

The willows are not known as boatbuilding timbers in England today, and are not particularly rot resistant, it is perhaps surprising that fastenings were ever made of the material. A type(s) of willow was probably used as all of them are rather soft and compressible whilst being elastic, thus they would conform to the hole in the oak and keep it tight, without acting as hard wedges. This would have been particularly important where fairly green boards were used.

2/ The Graveney Style- On close examination the lap fastenings of the Graveney boat proved to be quite distinctive and have since been found in many boat fragments from London broadly dated to the late 10th and 11th centuries (fig.92a,b,). They have also been found in burial contexts of earlier date in East Anglia (Bill 1994:59).

In this style small iron nails with rather irregular shanks were driven through plugs of soft pale wood and riveted over small quadrilateral roves. This was not done as some kind of repair but systematically for all rove nails. The luting was consistently of tarred hair, sometimes laid in a groove or 'cove'. Planking and keels with such fastenings have been found at Graveney, TEX 88, VRY89, and UPT90-BUF90 in London, all the elements were reused in the late 10th or 11th centuries (Goodburn 1994a).

Why use the plugs?

The plugs are hard to extract for species identification and could not be identified in the Graveney example, but at TEX88 the plugs were of alder (*Alnus sp*., Nayling Pers Com., Milne and Goodburn 1990:633). Again alder is a soft deciduous wood and easily compressed, thus it may have been used to cushion the wedging effect of the hard iron nails in green planking. Precisely how the nails were fitted without dislodging the plugs is currently unclear and would be worthy of experimentation.

3/ Iron rove nails without plugs- Some evidence of the use of larger square-shanked, iron rove nails is also known (Goodburn 1994a). In these cases the luting was of rolls of tarred hair and the roves were larger and mainly diamond shaped (fig.92a,c,). Planking so fastened was found one the VRY89, and BUF90 sites. Tree ring analysis shows the timbers to have been felled locally at the very end of the 10th or begining of the 11th centuries (Tyers 1994). The planking found has features closely resembling some Scandinavian finds (Goodburn 1994:103), except that in most Scandinavian finds the nails are round-shanked. Two fragments of clinker planking from 11th century contexts from one from TEX 88, and one from VRY89 ([5534] did have round shanked rove nails , and plied hair luting but could not be tree ring provenanced. The lack of cushioning wood in the lap fastening holes suggests the pre-boring of pilot holes was exactly judged and that the nails were produced to rather uniform dimensions.

4/ The Frisian style- The laps in the upper clinker planking of Low Countries or 'Frisian' style vessel found at UPT90-BUF90 were fastened with treenails. These were of willow (*salix-poplus*.) headed outboard and oak wedged inboard (Goodburn 1994:103). They resembled the New Fresh Wharf type but were slightly larger at c.20mm shank diameter. The luting and caulking were of moss held down with a batten and sintels as described below. The technical details and the tree ring analysis show that the parent vessel was built in the Low Countries area in the mid 10th century (Tyers 1994). Very similar fastenings were used in the Utrecht and Water Straat boats found close to Dorestad (Vlek 1987:74).

POST-CONQUEST LAP FASTENINGS

There is no current evidence known to this author of the Graveney or New Fresh Wharf style fastenings being used in the 12th century or later. A possible exception might be the line of treenail holes recorded along an upper hull plank from the Kingston No 1 boat (fig.92a,d,). The holes might either indicate the fastening of a rubbing strake or possibly the fastening of the sheer strake with treenails as in Kalmar 1 (Akerlund 1952:76). All the other lap fastenings from keel type craft which have been closely examined have proved to be large, square-shanked iron rove nails with quadrilateral or diamond shaped roves (Fig.92). Scarf joints were also fastened with rove nails of the same form but shorter.

Cog style laps fastenings; a rare English example

In the cog type plank fragments from PLS94 the lap fastenings were very different. Although corroded and damaged but it appeared that they were iron nails driven alternately from outboard and inboard, with the points turned twice (fig.92a,e,). The shanks were between 5-10mm square.

For the other finds the variation appears to have been subtle. Indeed, it was found during conservation work that some of the rove nail heads of the Kingston 1 boat may have been tinned (Ian Panter pers. com.). This is a practice used for some door rivets that were fastened in some cases at least by shipwrights (Goodburn 1991:107). Some of the galley building accounts of the 1290's actually specify door nails (see chapt.8). Thus, some of the variation in later medieval rove nails may only be visible when they are exceptionally well preserved.

How were rove nails clenched (cut and riveted over the roves)?

The first stage in fitting a typical rove nail was to bore a pilot hole just a little smaller than the nail shank, whilst the board was clamped in exactly the correct position. The next stage may have been to deal with the luting see below. The nail was then driven supporting the inboard surface with a solid iron tool (lump hammer, dolly, axe butt). Then the rove was snapped of the precut and punched strip such as have been found at several London sites, and driven over the nail tip with a hollow 'set' of hard wood or metal. Then the tip had to be cut and expanded over the rove drawing all tight, whilst the nail head was supported outboard. In recent English clinker work pincers have been used to cut the copper nails, but it has been unclear how this was done in medieval times.

A few of the lap rove nails from the 11th century 'Viking' style planking VRY89 [5484] and the early 14th century Kingston 1 vessel were so well preserved that clear impressions of blows with a chisel pein hammer could be seen on the deformed nail tips (figs. 82c, and 92a,d,). This evidence fits with ethno-archaeological observations of a traditional Norwegian clinker boat builder at work made by AE Christensen (Pers Com.). Here the boatbuilder bent over the nail tip protruding through the rove, against the rove with a hammer blow then cut it by using the sharply ground corner of the hammer as a swung cold chisel, whilst supporting the nail head. The practice of bending nail tips over roves as a stage in clenching is shown in a number of post-medieval finds see below. No clippers appear to have been used at all. It seems likely that this was a method known in medieval England.

EARLY POST-MEDIEVAL LAP FASTENINGS

Here there is an apparent tendency towards the use of smaller rove nails set closer together for the proportions of the planking (fig. 92a,f, Goodburn 1991:112). This tendency was well developed by the early 17th century even further towards the present day small copper rove nails used in recent clinker building in England. Typical rovenail spacings in medieval vessels such as Blackfriars 3 for example were about 150-170mm centres (Marsden 1996:68) whilst in Kingston 1 they were 150-180mm apart and in Kingston 2 about 160-170mm. In post-medieval finds of similar thickness planking this spacing may be reduced to 100-120mm, (eg. MGS96 [311], MOR88 [34] or BEY95 [538] etc, Marsden 1996:194, Table 4. below.)

In scarfs a new type of fastening appears for the first time in systematic use the small flat headed nail or large 'tack'. These were used to secure the outboard or less commonly inboard lip of scarfs where the weather can cause the timber to curl and the joint open. They have been recorded in both oak and elm planking of 16th century date from the following sites MOR88, MGS96, JAC96 and VIY97.

AN UNUSUAL FORM OF LAP FOUND IN REUSED PLANKING AT THE ABO92 SITE

A section of sawn oak boat planking was found reused in a mid 16th century context at the ABO92 in Southwark which had a very unusual form of lap. Fragments of another plank attached with conventional iron rove nails were found adhering to it, the luting being tarred hair. The laps were planed, sloping rabbets sometimes called 'ship lap'. The lap produced would have been almost flush but stronger and more watertight than butted carvel seams.

The seam must have opened somewhat in the life of the vessel as a very thin oak lath had been tacked over it followed by a thin oak tingle. The surfaces had a thick layer of cream coloured paint almost certainly 'white lead'('whitestuff). These features suggested that the parent vessel was old when broken up. The function of the two recesses shown is unclear. Exactly where the plank came from in a vessel is unclear, but it must have been close enough to the waterline to require luting. The thickness of 55mm suggests an origin in a large boat or ship.

TABLE 4. WEIGHTS OF SELECTED IRON LAP FASTENINGS; from c. 900-1600AD.

Notes- The weights given for each example, or averaged figures are for the finished rove nail and can not be highly exact as each nail varies. Also the cut off nail tip is not included, so the iron actually used for each fastening would have been a little greater than that cited. The scales used were a moderately accurate triple beamed balance. For dating methods see entries in Append.6. and references given below.

* = notably corroded

Site code and context.	Date	Weight grams.	Av. Board thickness.	Spaced centres.
TEX88 1743	10th	* 15	30mm	130mm
Skuldulev 5 (replica).	11th	34	c.24?	?
HOR88 No.2	14th	80	c.45	160
HOR88 No.3	14th	80+	c.50	160
Blackfriars N03	c.1400	*50	c.35	160
ABO92 5291	14th	*80	c.35	200
ABO92 Loose nail	16th	*160	-	-
JAC96 301	c. 1600	18	c.32	100
BEY95 538	E. 17th	15	30	100

Note - Information on the Skuldelev 5 replica nail weights from Crumlin-Pedersen 1997:187, for Blackfiars 3 boat entry Marsden 1996:65,68,94.

STRAKE TO FRAME FASTENINGS

For all the planked craft, large and small treenails were the principal strake to frame fastening. It was clearly more practical and cheaper to use a wooden fastening due to the length required. However, there are clear dateable trends in the archaeological evidence (Table 3). For example, in the 16th century some iron spikes (large nails) were also used, particularly in carvel built vessels . By the 17th century iron rove nails were even being used for frame to plank fastenings in some lightly built clinker craft such as Blackfriars 2 .

Variation in treenail types

On current dating oak-wedged, willow, botanically *Salix or Poplus sp*. (but see chapt. 8) treenails predominate before the 14th century. The oak treenails that occur in pre 14th century vessels appear to be associated with repairs. In the 14th and 15th centuries oak wedged oak treenails were adopted, and were universal in the post-medieval period (fig.92). The use of willow may have been related to its compressible nature (see above). The use of stronger but harder oak may have been linked to the use of more seasoned, thicker, less easily split hull planking in the later periods.

In English work pronounced outboard heads (often depicted in medieval ship images) gradually disappeared and parallel sided treenails wedged at both ends were adopted. There were many ways of expanding treenail ends, some versions are clearly.

How were frame treenails or 'wrong nails' made?

It is clear from documentary sources that treenail making was an ancillary trade in later medieval times several hundred were needed even for a humble river barge (chapt 8.). Treenails in our period were made of cleft wood shaved to a regular diameter very slightly larger than the augured pilot hole. It is not entirely clear how this was done even where partly made treenails have been found (Crumlin-Pedersen 1997:124). The closely examined finished examples were clearly facetted not made perfectly cylindrical by turning as in some Roman examples (Rival 1991:232), or using a rounder or 'moot' as in recent times. Several different tools such as draw knives, Stock knives, broad hachets and froes may have been employed, more experimental work may elucidate this matter. The outboard ends of some, or probably all of the earlier treenail holes were countersunk using a few strokes with a knife held obliquely to judge from the marks surviving on Kingston 3. This ensured a snug, more leak proof, fit for the head.

APPENDIX - 10 SOME GENERAL NOTES ON FRAMING TIMBERS FROM THE LONDON CORPUS OF BOAT FRAGMENTS C.900-1600AD

LESS COMMONLY RECYCLED MATERIAL

Framing timbers in planked medieval vessels were generally more awkward shapes to reuse than planks or hull slabs. In the London region they are comparatively rare finds, for this reason and because many aspects of their production changed less through time than hull planking and boards they are only considered in outline here.

Terminology

The terms used for framing elements are many and varied in English, the following section uses the most common terminology much of which was in use by the 13th century (See Append.1).

PRE-CONQUEST EXAMPLES

Here the Graveney boat has to set the standard for comparison (Fenwick ed. 1978, and McKee 1978). The framing system comprised alternating 'long and short arm' floors, the larger curved floor timber crossed the bottom of the vessel and was edge-halved scarfed to a short curved futtock (fig.27). The frame timbers recovered were all of oak with the grain more or less following the hull shape in most cases, and were surprisingly heavy of a deep cross section. When viewed in plan they were rather crooked, not always running straight across the vessel. Nor were most cut to closely fit the stepped outline of the pre-erected shell of strakes. They contrast markedly with the framing used in broadly contemporary Scandinavian vessels where the, generally much shallower, lighter and straighter framing system employed included many integral cross beams ('bitr') as in Skuldulev 3 (fig.9). The vast majority of frame elements in the Scandinavian style vessels were also 'joggled', or cut to fit the stepped hull strakes. In some Scandinavian style vessels frame elements were elegantly sculpted and even moulded (eg. Hedeby 1 Crumlin-Pedersen 1997:229). The splayed fish tail frame end still attached to long ship planking found at VRY89 is an example of this sculpting (fig.82).

Clearly the regularity of the framing was not as important to Graveney's builders as it was to the builders of Skuldulev 3. One feature in common was that the floors in neither style of construction were fastened to the keel.

A distinctive point of framing insertion

Another important practical difference between the Graveney style of framing and that of vessels like Skuldulev 3 is that the fitting of the frames could only happen when the planking up was fully completed. This would have been comparatively awkward. In the typical Scandinavian framing system some or all of the floors could be fitted once the planking had reached the bilge, stabilising the hull shell at that point. It would have been much easier to get a good fit at this stage.

FRAGMENTARY FINDS FROM LONDON

Floors and futtocks

Oak frame elements very much in the Graveney style but sometimes with more joggling have been found reused on the London waterfront, one at TEX88 and six at UPT90 including both floors and futtocks (fig.96). Most were reused as piles, and dated by their position in the site sequence to the 10th to 11th centuries. Traces of treenail fastened edge halved scarfs sometimes survived together with some toolmarks which were essentially similar to those on the Graveney timbers. The small fragment from TEX88 [905] was joggled to fit strakes about 40mm thick more than the c. 28mm thick Graveney boards, thus it probably came from a larger vessel. It was hewn from a whole log with c.40 annual rings leaving much of the sapwood. This contrasts with the much older material used in the Graveney vessel where, in the two frame elements examined, parent trees appear to have been slow grown and just under 200 years old .

The short floor timber sections from UPT90 were rather similar to those of the Graveney boat with little joggling and a deep cross section up to 250mm deep.

Bitr and knee fragments

A few knee timbers have been found of pre-Conquest date in London. An oak combined cross beam and knee, 'bitr' (UPT90 [7265]) was reused in a building floor of the 11th century and in fragile condition. However, it is clear that it was hewn and cleft from the upper part of a largeish oak with a section of the stem and a limb combined. A hole in the side may have been for running rigging. Another small fragment of a 'grown' oak knee was found at the same site which might also have been from a bitr .

At NFW74 an interesting 10th century oak knee was found Marsden 1994:144) that was not cut from a grown crook, but a thick straight grained slab of cleft oak with the grain set diagonally across the angle of the knee. This is often done now by modern English boatbuilders who do not make the effort to obtain naturally crooked raw material. Perhaps the implication here is that the builder was in a hurry and could not wait for the next batch of crooks?

Possible small vessel framing

Only three frame elements have been found broadly dated to this period in London. The example from TEX88, hewn from a tightly curving oak branch is unjoggled and so small it may perhaps have derived from an expanded dugout, rather than planked vessel. A larger example from UPT90 was hewn from a larger log which was not really curved in quite the correct direction perhaps for the reasons cited above. A small fragment of treenailed tightly curved boat framing was also found at NFW74 which was made of fruit wood (Marsden 1994:144). This is particularly interesting as it is the only non-oak vessel framing element found in London to date of any period, and foreshadows the practice of some modern English clinker boatbuilders who used naturally tightly curved fruitwood crooks for knee in small boats. In some Scandinavian vessels a very surprising range of species was used for framing including alder, lime, willow, and maple in the Skuldelev and Hedeby late Viking vessels (Wagner 1986). The principal problem with the use of these materials to modern eyes is lack of natural rot resistance, and in the case of alder and lime comparative softness and weakness. The builders apparently chose the logs for their shape rather than strength and durability.

SOME MEDIEVAL EXAMPLES

The framing of Blackfriars 3

The hull shape of Blackfriars 3 could be described as a slightly flattened version of the Graveney form in which a virtually straight floor timber had two curved futtocks edge halved scarfed onto the ends (fig.96). This arrangement would have been very much easier to fit than the Graveney type, and the logs required were simpler shapes. The floors could also be fitted when the planking had reached the bilge for example. A key draw back was that having the main joints in the framing in the same part of the hull was a weakness requiring extra support. The framing appears to have been reasonable closely joggled to fit the strakes, and were comparatively shallow in moulded depth. Thus, it appears that the Scandinavian framing arrangements had been adopted by this time?

Two crudely shaped oak frames from VAL88

Two rather roughly shaped curved oak frame elements were found reused in a 12th century clay and timber river embankment at the VAL88 site on the eastern bank of the filled in Fleet river. Both timbers (VAL88 [12288],[12290]) were strongly curved and probably originally floor timbers from towards the ends of the parent vessel. Their scantling suggests an origin in a smallish craft. The axe cut 'V' shaped holes were probably limber holes for the free running of bilge water. Clear traces of joggling for clinker planking are not very distinct, therefore the timbers might derive from a smooth skinned vessel or simply be crudely made. Timber [12288] has an edge-halved scarf at one end to join to a futtock (fig.96).

NOTES ON SOME OTHER FORMS OF FRAMING KNOWN DURING THIS PERIOD

Cog style framing

Whilst there was variety in the style of framing used in vessels built in the cog style (Reinders 1985) the majority are distinctive. The framing was of oak with a greater siding (width) than moulding (depth), and it was joggled where it bore against clinker strakes. The system also involved the use of fairly widely spaced heavy cross beams, often notched through the hull sides, with additional deep knees (fig.22).

Keel framing outside England

To supplement the current English lack of evidence for the framing deeper sea going keel-type craft we can look to Kalmar 1 as a model for coasters at least. Here oak floors, were through-splayed scarfed to futtocks and combined with fairly widely spaced multiple cross beams some of which pierced the hull (fig.15). Tentative English evidence of the use of such beams and knees in vessels deeper than Blackfriars 3 comes from the HOR88 site where an oak ship cross beam was found reused with the Kingston 1 boat planking (fig.96). The bevelled ends show that it derived from the ends of a vessel. It would appear that it probably lapped over the floor heads and that the cross frames were not perfectly aligned so on one side it lapped round the timber but not on the other. The treenail and iron nail fastenings for two standing knees were found, and coincidentally the roughed out knees found at the site might have been destined for such a use (Chapt.8).

HOW WERE PRE AND POST-CONQUEST FRAME ELEMENTS MADE?

Few medieval frame elements have been systematically examined but by interpreting the detailed drawings of the frame elements of the Graveney boat (McKee 1978:49) and considering some other evidence a summary description of frame making can be presented. The axe incut marks left from cutting scores for 'notch and chop' hewing have been recorded on some of the fragmentary London finds, and are illustrated on several of the Graveney floors. The smoothing of the faces was carried out using similar axes at about 45 degrees to the grain although some marks labelled as slight scratches may have been broad axe marks. Fairly narrow axe stop marks, often forming a herring bone pattern are shown on the faying surfaces of several Graveney floors, and the joggles and limber holes of the London finds were clearly cut with relatively narrow bladed axes.

The use of curving logs roughly the right 'grown' shape appears to have been the case with most of the Graveney timbers, although two areas of short grain resulted in breakage. The London finds were rather short for the parent logs to be reconstructed, but it is possible to note that where the curve was marked the grain followed in most but not all cases.

SOME POST-MEDIEVAL EXAMPLES

Clinker vessel frames a new approach

The framing of the most complete post-medieval clinker built vessel to have any substantial record the Blackfriars 2 boat of the 17th century (Marsden 1996:145) the additional internal strengthening timbers are ignored here) is distinctively different to that of medieval vessels. It is of comparatively light scantling,many of the floors were well under 100mm moulded and fastened with iron rove nails rather than treenails (Marsden 1996:148). Judging from the drawn grain of the timbers they were often if not all cut from slabs of rather straight grained timber so the ends of some floors would have been weak. This use of slabs or 'flitches' of oak rather than small curved logs pre figures modern practice for wherry building on the Thames.

Only two reused sections of post-medieval clinker vessel frame timber have been, found in London reused as stakes at VIY97 and 245BR. However, in both cases the joggled oak timbers had been axe (or less likely adze) cut from a 1/4 of a log, rather than a whole log as was typical of the medieval material.

Carvel vessel framing

The methods of framing of post-medieval carvel built vessels is a large and complex area in its own right which can not be extensively outlined here but a few key points are relevant. In the shell-first approach to carvel building (Marleveld 1994) most or all of the framing is not fastened together, whilst in skeleton first carvel nearly all elements are fastened together. In early carvel vessels elaborate time consuming methods were used for constructing whole pre-errected frames using carved keys treenails and spikes (Redknap 1984:99). The smaller reused carvel vessel frame finds from London (site BEY86 Goodburn 1991:113) show no treenail or bolt edge fastening. The issue of fastening frame elements to each other is currently under study in the case of the Mary Rose (Dobbs Pers Com.). The floor timbers were often bolted to the keel unlike many medieval examples

How were they made

In some cases clear axe marks have survived on the sides of the frame timbers found at BOY86 whilst adze marks are clear on the moulded edges (Goodburn 1999b). In others cases the timbers had been cut from logs halved with using a pit saw. The curve of the grain appears to have been carefully selected in most cases.

APPENDIX -11 NOTES ON LAP, SEAM AND SCARF WATERPROOFING METHODS C. 900-1600AD

Laps and seams, 'caulking' and 'luting'

There were many ways of making joints in hull planking watertight in our period sometimes these are simply referred to as 'caulking' (McGrail 1987:129, Marsden 1994:13). However, this term lumps together several quite distinct methods of plank edge sealing associated with different building practices in different areas. Essentially in all clinker vessels the method used was to insert animal or vegetable fibres set in a mastic (usually some form of wood tar) before fastening elements together during construction ie. 'luting'.

Driving in the material between the planks or 'caulking' was occasionally carried out during repairs to cure a leaky seam, if this was carried out with a different material it could be clearly seen. This was the case with some of the articulated, treenail fastened, 10th century clinker boards from UPT90. These were moss luted originally and had repairs set in tarred hair.

Often the materials used for luting seem to have been a prescribed part of the particular style of construction, as in the contemporary New Fresh Wharf and Graveney styles of construction. Here moss was used in the former (Marsden 1994:145) and tarred animal hair (wool) in the latter Fenwick ed.1978:95-7) . There is some evidence that preferences for particular materials changed through time wool, goat hair, cattle hair, or moss waxing and waning in popularity (Walton 1988). It is clear that the study of animal hair luting also can provide information about aspects of the development of animal husbandry, thus it is a particular shame that all the samples taken since 1988 in London have not been analysed. The study of the mosses used has not been systematically carried out so little more can be said now.

Caulking

It is well known that cog-type vessels were caulked with tarred moss held down with a lath fastened with iron sintels (fig. 23 after Reinders). It is also the case that the fragments of what must have been a Frisian Hulc were also caulked in a similar way (see Chapt.7 and fig.68a). Here an opening was deliberately left inboard at the top of the lap in the upper planking and join to the dugout base. The moss was then driven or pushed in after the treenails holding the lap were fastened.

Caulking with vegetable fibre was found in the laps close to scarf ends in some 16th century clinker articulated boards at sites JAC96, and MGS96, in London. However, these parent vessels were luted for the most part.

Early carvel vessel caulking

The 16th century deposits of shipyard debris at London site VIT96 included much loosely rolled animal fibre caulking material. As this material was associated with exclusively carvel shipbuilding debris we must assume animal fibres rather than the better known oakum of vegetable fibre was used there in c. 1582 (Append.6).

HOW AND WHEN WAS THE LUTING APPLIED DURING THE CONSTRUCTION PROCESS IN ENGLISH CLINKER VESSELS C.900 TO 1600AD?

Practical experimentation with the early stages of adding clinker boards to the Kentmere reconstruction and building a short section of clinker ship hull in 1998, shows that the luting must have been applied after the boring of the lap fastening holes and removal of the board from the hull. The luting was applied to wood tar painted along the trimmed lap just prior to final fitting and the driving of the lap nails. The tar or similar mastic holds the fibres in place during the reclamping for fastening in position. As the fastenings are tightened excess tar is squeezed out of the lap and impregnates the fibres. Luting coves or hollows to hold rolls of luting were only occasionally seen, usually the lap was hewn flat or slightly concave right across its face.

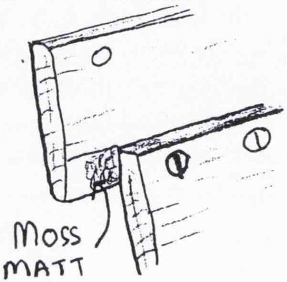
Rolls, plys, matts and old textiles

The moss luting examined in the London finds appears to have been laid out as a random matt on the tar in the lap, whilst several different approaches were used for the animal fibres used. For brevity the various systems used are illustrated in the summary table below. Old scraps of what appears to have been woven tarred textiles have been seen occasionally under tingles and in scarfs as in the HOR 88 1 boat repairs.

TABLE 3. THE MAIN ARRANGEMENTS OF LUTING MATERIAL RECORDED IN THE LONDON CORPUS OF CLINKER BOAT BOARD AND PLANK FRAGMENTS, SOME SELECTED EXAMPLES.

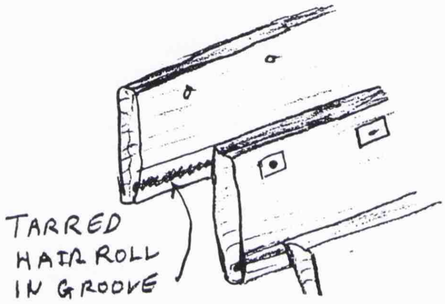
SITE CODE   DATE   STYLE OF LUTING

NFW74   C10TH
UPT90
TEX88
VRY89
BIG82
BUF90

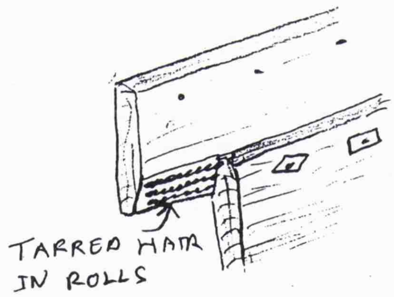


GRAVENEY   C10TH TO C11TH
TEX88
UPT90
VRY89
BUF90

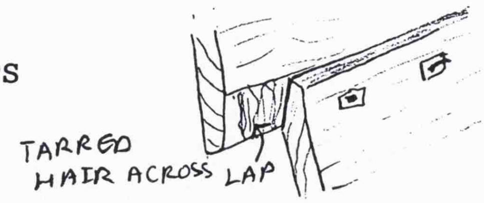
TEX88   C11TH
BUF90
VRY89



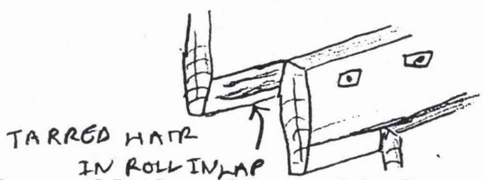
CU73   C12 TO C14TH
HOR88 1
HOR88 2
HOR88 3
BLACKFRIARS 3
BIG82
TYT98
ETC.



MOR 87   C16TH
MGS 96   IN ELM PLANK LAPS
TWE 98



MGS96   C16TH
JAC96   IN OAK PLANK LAPS



Note the spin direction in the rolled and or plied material has not been systematically examined.

SCARFS

In scarf joints in clinker vessels the sealing material has to be applied during construction ie. it is luting. Where it has been possible to study the material used it was normally the same as that used in the laps. The fibres of hair or moss could be laid in mats or rolls and all had to be tarred or resined for the same reason as the laps.

APPENDIX - 12 SURFACE TREATMENTS , PAINTS, ETC

Most types of freshly worked timber require some surface sealing to slow seasoning distortion for nautical use (Chapt.5/6). In planked vessels where this issue and the display of status through decoration apply the sealing may have taken many forms but a full survey can not be presented here. However, we may note that we have historical and or archaeological evidence from London for the use of, oils, pine tars, resins, and pigmented paints for the period c.900-1700AD (Goodburn 1991:113, Marsden 1996:208).

Although surface layers on nautical timbers of our period found in London since 1988 have been extensively sampled relatively few have been analysed. Despite this it is clear that pine tars ('Stockholm tar') and resins appear the most used materials in every period, from the scant evidence on 10th-11th century reused timbers at UPT90 (Stainer 1993) to the thick deposits found on 16th century clinker planking reused at MOR88. By the 16th century the archaeological evidence shows that surface treatments were being heavily used, particularly wood tar, and thick cream deposit that appears to have been white lead paint (then known as 'white stuffe',). By the 17th century many pigmented lead paints were being used in large vessels whites, blues, reds, yellows and black being common (H. Ganiaris Per Com. B0Y86). The increasing use of heavy paint layers may also be partly due to the increasing use of less stable sawn oak and elm in construction.

Resin based paints have been found in early medieval contexts on some shipboards from Dublin and on parts of the 11th century Hedeby 1 ship (McGrail 1993:137, Crumlin-Pedersen 1997:86).

In Sum

This whole important area is clearly under researched at present and worthy of more study including experimental work. The new find of planking from a large 13th century galley at TYT98 London, was thickly covered in both black to brown tarry deposits and cream coloured 'paint'. Samples have been taken and it is hoped proper analyses will be carried out. This field is surely a case of 'spoiling the ship for a hapeth of tar', as the saying goes.